JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

VOL. 19 MARCH, 1928 No. 3

THE WATER SUPPLY OF ROCHESTER, N. Y.[1]

By IRVING E. MATTHEWS[2]

Rochester is the fortunate possessor of a municipally owned water supply of exceptional quality. It consists of a dual system. The domestic supply of pure, soft water is brought from Hemlock Lake by gravity, so that the cost of pumping as well as filtration, so common to most cities, is avoided, while the direct pumping system taking water from the Genesee River affords additional fire protection in the congested downtown district.

The privately owned Rochester and Lake Ontario Water Company supplies portions of five wards of the city and the surrounding territory. Its water is pumped from Lake Ontario to a sedimentation basin and re-pumped through pressure filters to the distribution system and an equalizing reservoir of small capacity.

The City of Rochester is bisected by the Genesee River which flows through it from south to north. The river has three falls and several rapids within the corporate limits, having an aggregate descent of about 257 feet, affording valuable water power, very largely utilized by the Rochester Gas and Electric Corporation. The Erie Canal also, formerly, bisected the city from east to west. These two factors were very important in the early development of the city. The former furnished power for manufacturing and the latter furnished

[1] Presented before the New York Section meeting, October 27, 1927.

[2] Superintendent, Bureau of Water, Rochester, N. Y.

the means of transportation for both the raw materials and the finished products. They were also important in the early supply of water for the suppression of fires.

EARLY SOURCES

In pioneer days the domestic supply was obtained from shallow wells sunk in the underlying limestone from which a copious supply of rather hard water was easily obtained by means of the "old oaken bucket" or a "town pump." The supply for laundry purposes was obtained by collecting the rain which fell on the roofs into cisterns. Fire protection was afforded by a bucket brigade which dipped water from the Genesee River or pumped it from nearby wells.

Upon the completion of the Erie Canal in 1824 it at once became the chief supply for fire purposes and remained such until the introduction of the city's present water supply in 1874. During the season of navigation the water was obtainable without expense and in the winter it was retained for the purpose by the yearly construction of dams in its channel. At a later date the water was conducted in iron pipes at considerable expense to cisterns constructed beneath the surface of the streets, located at points convenient for use in cases of conflagration.

Do not think that the question of water works was sleeping during these 50 years of primitive supply. As the city grew the wells became contaminated and the water became unfit for domestic use. There was naturally much discussion and many demands for an adequate water supply.

In 1835 one year after the city was incorporated the legislature of the State granted a charter to the first Rochester Water Works Company (L. 1835 Ch. 175). The company was capitalized at $10,000, but there is no record to show that it ever did more than effect its organization. In 1838 Elisha Johnson, then Mayor of Rochester, sent a communication to the Common Council recommending a supply of water to be pumped from the Genesee River, but no action was taken.

In 1852 another water company was chartered by the State legislature (L. 1852, Ch. 356) under the same name as the company of 1835. It was authorized to expend the proceeds of $800,000 in bonds and $800,000 in stock. The company organized and obtained a liberal contract from the city for the supply of water for public use. How-

ever, nothing was done toward obtaining a supply of water and after patiently waiting for eight years, the Common Council employed Daniel Marsh, a civil engineer, to prepare a report on "The Introduction of a Supply of Pure Water into the City of Rochester." This report enumerated a number of possible sources of supply and is of interest because it was the first suggestion that water be taken from Hemlock Lake.

Later in this same year (1860) Mr. Marsh became the Chief Engineer of the revived Rochester Water Works Company of 1852, and began making plans to obtain water from Honeoye Creek, the outlet of Hemlock Lake, at a point about 18 miles south of the city. After several years of desultory work a system resulted consisting of $16\frac{1}{2}$ miles of 24-inch wooden-stave pipe hooped with flat iron, a 70 million gallon reservoir, 9 miles south of the city, partly built, and a small basin or so-called distributing reservoir on the ridge at the southern boundary of the city, about 13 miles of distribution pipe, partly cast iron and partly wrought iron pipe lined with hydraulic cement, and a few hydrants, but no water. No provision had been made to let the air out of the wooden pipe, and when water was turned on it would not flow over the summits, and the leakage was so great that the line was considered a complete failure. Soon after this the mortgage on the property was foreclosed and a sale made to Thomas B. Rand and others in 1872.

MUNICIPAL EFFORTS

Meanwhile the citizens of Rochester, who had patiently waited twenty years for the company to furnish them with water, became disgusted and suspicious of ever obtaining water from a private company. An appeal to the State legislature resulted in an "Act to Supply the City of Rochester with Pure and Wholesome Water" being passed on April 27, 1872 (L. 1872 Ch. 387). By this Act a Board of Water Commissioners was created with authority to construct a system of water supply by means of money borrowed upon the credit of the city. The Board immediately engaged Mr. J. Nelson Tubbs as its Chief Engineer and the wisdom of this choice was soon demonstrated. The Common Council and the friends of Mr. Rand at once applied to the courts to restrain the Commissioners from proceeding under the Act, but in the following June the injunction was removed and the work was allowed to proceed.

On November 15, 1872 the Water Commissioners submitted to the Mayor their report in which they said "We join in the recommendation of the Chief Engineer that the compound system of gravity works from Hemlock Lake for domestic use and the Holly works for fire purposes would prove by far the most valuable to the city at large and the most economical in annual cost of operation." The report was approved by the Mayor, and the Board then proceeded with the work, first obtaining from the State legislature authority to "enter upon, control and use the waters of Hemolck and Canadice Lakes" (L. 1873 Ch. 754).

The Board enjoined the Common Council from entering into the proposed contract with the Rochester Water Works Company, and, they retaliated by several actions all of which failed, and the complete demise of the private company occurred on August 18, 1882 when the City paid them the sum of $26,000 for certain real estate and water rights owned by them.

THE HEMLOCK LAKE SUPPLY

Early in 1873 contracts for the construction of the works were let and on February 18, 1874 water was turned on the Holly System for an official test which was very successful and highly gratifying to the citizens of Rochester. The test aroused national interest and the Daily New York Graphic contained several pictures and a full description of the works. The conduit from Hemlock Lake was completed late in 1875 and on January 23, 1876 Hemlock water was flowing into Rochester, less than 3 years after actual work was started by the Water Commissioners.

These works so wisely planned and carefully constructed over 50 years ago are still serving our city. However, the increase in population from 70,000 in 1870 to over 300,000 at present, made necessary, from time to time, many additions to the original plant. A second conduit from the lake was constructed in 1893–94 and a third in 1914–18. Also an additional distributing reservoir on Cobb's Hill was constructed in 1908.

The reason why our water supply is of such excellent quality is because it comes from spring fed lakes located in the hills about 30 miles south of the city in a region described by Lafayette, one hundred years ago, as the "Switzerland of America."

Hemlock Lake is a clear sheet of water about 7 miles long, a little

more than half a mile wide, and from 40 to 90 feet deep. It is about 390 feet above the general level of the city and lies between high hills at the north end of a deep, narrow valley which is about 15 miles long. The basin of the lake is deeply excavated in the so-called Marcellus shale, a distinctly stratified, but soft argillaceous rock. The shores consist of a beach made up of water worn fragments of shale, free from vegetation. The rapid deepening of the water, as it recedes from the shore and the absence of mud from the bottom give little foothold for aquatic plants, which are usually so abundant in shallow water. The water is practically always clear with no turbidity and its hardness is between 60 to 70. The watershed of the lake is about 48 square miles and the water surface area is 1828 acres. When the dyke now being constructed at the foot of the lake is completed 5 feet additional storage will be available. This will give an estimated storage capacity of $11\frac{1}{2}$ billion gallons.

Canadice Lake, lying parallel with Hemlock on the east, being separated from it by a high ridge, is about 3 miles long, one quarter of a mile wide, and has a maximum depth of 84 feet. It is 200 feet above Hemlock Lake, and has about 12 square miles of watershed. The water surface area is 648 acres, and by means of a bulkhead built at the outlet, and a low dyke at the foot of the lake, about 6 feet storage is obtained, or $1\frac{1}{3}$ billion gallons. Just below the bulkhead is a concrete weir for measuring the flow from the lake.

The outlet of the lake has a length of about 4 miles before it joins the outlet from Hemlock Lake. The watershed of the outlet is about 6 square miles, and in order to utilize as much of the water as possible a low dam was constructed near the mouth of the outlet to divert the Canadice water through a 5-foot circular concrete conduit into Hemlock Lake. This was put in operation in 1919 and because the sanitary control of the outlet was not as effective as on the Lakes a liquid chlorinating plant was installed on the connecting conduit in 1922.

The construction of the water works brought to the attention of the citizens of the city and the surrounding towns the beautiful natural scenery about Hemlock Lake. As a consequence it became a popular resort for our citizens during the hot summer weather and for 20 years the number of visitors constantly increased, until there were 3 or 4 large hotels and about 150 cottages along the shores. The garbage and excreta produced in all of these habitations was collected in covered pails daily and buried in shallow trenches on

lands of the city just below the foot of the Lake. In 1894 the Hemlock Lake Improvement Company was incorporated to erect a large summer hotel and lay out some 800 cottage lots along the shores of the lake. The citizens of Rochester became alarmed and feared that the purity of the water of the Lake could not be maintained if this project was carried out. They applied to the State legislature for authority to provide for the sanitary protection of the sources of its water supply. An Act was passed in 1895 (L. 1895 Ch. 1018) giving the city authority to appoint a Commission to purchase a strip of land 200 feet in width around the shores of Hemlock Lake. The Commission promptly proceeded with the work which was completed in 1902, having acquired practically the entire lake frontage. The city removed all of the cottages and hotels and restored the shores to their primitive condition.

Considerable land has been acquired by purchase beyond the 200-foot limit, so that the city now owns on Hemlock and Canadice lake watersheds about 4000 acres. The practice of planting this land with white pine, scotch pine and Norway spruce seedlings obtained from the New York State Conservation Commission was begun in 1902 and has been continued each year since. In 1917 the use of white pine was discontinued due to the prevalence of "Blister" and since then scotch pine has been exclusively used. The total number of trees planted to date is about 1.5 million.

SUPPLY CONDUITS

The water from these Lakes is brought to the city by gravity through three metal conduits.

Conduit No. I built in 1873–75 is a compound conduit $28\frac{1}{4}$ miles in length, the upper 10 miles being of wrought-iron, 36 inches in diameter, and the rest of the line of 24-inch wrought and cast-iron. The daily capacity of the line is 6,500,000 gallons. The lake end of this conduit terminates about 1000 feet from the shore where the water is about 35 feet in depth.

This conduit is of some interest because it was designed by Mr. Tubbs to deliver 7 million gallons per day and it was found by actual test to deliver over 9 million gallons, as measured by his Assistant Engineer L. L. Nichols, soon after it was put in service. This difference between calculated and actual capacity resulted in a rather heated controversy among hydraulic engineers some thirty

years ago during which this test was called "The Rochester Crime against Hydraulic Engineering." The writer began his engineering apprenticeship under Mr. Nichols and knew him to be a very precise and conscientious engineer and the suggestion that he made a misleading report is incredible.

In designing this compound conduit, Mr. Tubbs had to use the Weisbach formula in a somewhat modified form, because he proposed to deal with two different diameters and lengths. At that time every formula for the flow of water in pipe was based upon the assumption that the diameter of the pipe was uniform throughout its entire length.

Another interesting novelty in connection with this conduit was the use of wrought-iron pipe. Although several miles of this kind of pipe had been laid by the Spring Valley Water Company of San Francisco, Calif., it had never been used in the East, but when Mr. Tubbs found it would save about $750,000 he boldly decided to use it in constructing the Rochester Conduit. Time has proved the wisdom of his choice, for after 50 years of service the maintenance charges on this line are very small. The pipes were made of boiler plate iron riveted and caulked in lengths of about 28 feet in the same manner as for steam boilers. They were then heated and plunged in a bath composed of a mixture of asphaltum and coal tar heated to a temperature of about 300° Fahr. After from 20 to 30 minutes they were removed and allowed to dry before transportation. Three of these lengths were riveted together in the field and the resulting length of 84 feet lowered into the trench, and the bell and spigot ends connected with hot lead joints. The bells were of cast-iron and were riveted to the wrought-iron pipes.

In 1877 a telegraph line was constructed by the city from Rochester to Hemlock Lake to facilitate the management of the water works. At first Morse recording instruments were used, but in a short time these were replaced by the then recently invented Bell Telephone receiver and transmitter. This line is still in use, but at the time of its construction it was regarded with considerable curiosity, as it was then the longest telephone line in actual use.

The second line, Conduit II, was designed and built in 1893–94 by the late Emil Kuichling, then Chief Engineer of the Water Works. It consists of three main parts, the intake pipe, the masonry conduit and the steel pipe line.

The intake pipe consists of 1550.93 feet of 60-inch steel pipe.

These pipes were riveted together so as to make 15 lengths of about 100 feet, each provided at the ends with the proper parts of a ball-and-socket joint. The outer end was provided with a wide flaring mouth-piece anchored within a strong timber crib which was sunk to the bottom of the lake. The inner end was anchored by the masonry walls of the gate and screening house.

The masonry conduit extending northerly from the gate house is $2\frac{1}{4}$ miles in length and consists of a brick lined horseshoe-shaped tunnel, 6 feet wide and high, laid on a grade of 1 in 4000. The water leaving the gate house passes over a 10-foot weir for measuring the flow as it enters the tunnel. The greater portion of this tunnel was through a dense shale rock and the invert is from 50 to 80 feet below the surface of the ground. This conduit terminates in a brick overflow chamber, 34 feet in length, which prevents the water surface from reaching the top of the arch of the tunnel, and from which the metal pipe conduits begin. These upper works were designed for a capacity of 32 million gallons per day which is the estimated yield of the watershed.

From this overflow chamber two lines of metal pipe extend northerly about 26 miles to the various reservoirs of the city. Only one line, Conduit No. II, was laid in 1893–94 consisting of a 38-inch riveted steel pipe having a capacity of about $16\frac{1}{2}$ million gallons per day.

This steel pipe line has caused considerable maintenance expense by reason of leaks due to corrosion by pitting from the outside. The first hole was discovered in 1900, about 6 years after the pipe was laid, and at present from 50 to 60 leaks a year occur. The method employed in repairing these pits is to uncover the pipe and insert a pine wood plug in the hole, cutting it off flush with the outside of the pipe, then a rectangular patch of sheet lead followed by a sheet steel patch bent to the curvature of the pipe is placed over the spot and pulled down tight by a flat iron band with two bolts, the lead is then upset around the edge of the patch with a caulking iron.

When the laying of this line was first begun the coating material used was California asphalt, but as this material began to exhibit signs of disintegration a change was made to a mixture of Trinidad asphalt and coal tar pitch. Later, after about one-half of the line had been laid, another change was made to Sabin's baked japan. After the development of the pits a very careful investigation was made and it resulted in the adoption of a lead and graphite paint for the

first coat, a graphite paint for the second coat and the third and final coat to be of "Trus Con Special Paint," made of Cuban asphalt, Chinese wood oil and other ingredients. About 8 miles of this conduit has been uncovered and repainted at an expense of about $16,000 per mile.

By 1913 it became apparent that the two conduit lines would not supply the increasing consumption of water in the city, and so the third line, Conduit III, was laid from the overflow chamber at the end of the masonry tunnel to Rochester. The first section was laid in 1914 consisting of 37-inch case iron pipe, extending northerly from the overflow for about 8 miles. The rest of the line was laid in 1916 and in 1918 and consists of 37-inch Lock-bar steel pipe. This line has a daily capacity of about 19 million gallons. Steel pipe was adopted in the last two contracts because the difference in cost between cast iron and steel was about $50,000 in favor of the steel. It was estimated that the saving of that amount would create a fund sufficient to keep it in repair and not entail unwarranted expense upon a future generation.

The first leak from pitted pipe on this line occurred in 1921 about 5 years after the pipe was laid, but the leaks on this line have not been as numerous as on Conduit II at the same age, so that it is probable that the protective coating on this line is more effective than that on the previous line.

There are 3 reservoirs connected with the system, a storage reservoir at Rush, about 10 miles south of the city, and 2 distributing reservoirs on the high ridge in the southern part of the city.

RESERVOIRS

Rush Reservoir was built in 1873–75, partly in excavation and partly in embankment, with clay puddle bottom and core-wall, the inside slopes being paved with stone, its area is about 14 acres and it has a capacity of 63½ million gallons at a maximum depth of 16½ feet. Its elevation above the general level of the city is 248 feet. All three conduits, as generally operated, flow into this reservoir over a measuring weir. They may be by-passed, however, but as usually operated the water flows into Rush reservoir and out again, passing through Venturi meters installed on each conduit. In 1925 a chlorinating device was installed here and all water is chlorinated as it enters the reservoir. This was done merely as a measure of precaution against possible pollution.

Highland Reservoir, in the southeastern part of the city, was built in 1873–75 and has a capacity of 22½ million gallons at a maximum depth of 15 feet. Its area is about 5½ acres and its elevation above the general level of the city is 128 feet. Its construction is similar to that of Rush reservoir. The water on entering is discharged, in summer, through a vertical pipe or aerating fountain which when first installed some 50 years ago aroused considerable favorable comment because of its attractive appearance. A submerged inlet is used in the winter.

Cobb's Hill Reservoir was designed and built by John F. Skinner, Deputy City Engineer, during the years 1905–08. It is located on the ridge in the southeastern part of the city and is at the same level as Highland Reservoir. Its area is about 18¾ acres and its capacity at the maximum depth of 25 feet is 144 million gallons. It was constructed partly in excavation and partly in enbankment, being lined with concrete throughout. The bottom consisted of a 3-inch course of concrete laid continuously in long strips, for convenience about 14 feet wide. To this the waterproofing was applied, consisting of 6 moppings of hot coal tar pitch and 5 layers of single-ply coal tar felt. Above this came the top layer of concrete 6 inches thick, laid in 12-foot squares with pitch joints. The side-walls were constructed of separate blocks of mass concrete 20 feet in length and about the same in height, 3 feet wide at the top and tapered 1 on 4 on the inside face and 1 on 5 on the back. A keyway 8 inches square between each block, filled with clay and sand, prevents leakage through the joints and permits tamping with a specially constructed light driver should any leakage occur. A central passage is left through the walls for inspection and one inch tell-tale pipes lead into the tunnel passage from the sand and gravel under the foundation. Their purpose is to detect and locate any serious break or leakage. The leakage has been extremely small. The water enters by either a submerged inlet or the aerating fountain. The valves are operated hydraulically or manually. Five specially designed balanced valves for operating the hydraulic gates are placed in a glass case in the gate house at the west end of the reservoir.

The land adjacent to both of the distributing reservoirs has been converted into public parks by the city, and the gate houses and other water works buildings were made somewhat more ornate than is usual in order to harmonize with their beautiful surroundings.

DISTRIBUTION MAINS

There are four 36-inch cast iron distribution mains, two from each of the distributing reservoirs, radiating in a generally northern direction, diminishing in size as they approach the outskirts of the city. They are tied together by many secondary feeders of 12 and 16 inches, and the minor distributors are 6, 8 and 10 inches,—6 inch being the minimum now used. Dead ends are avoided as far as possible, and the hydrant spacing is usually about 320 feet. There are at present about 500 miles of distribution mains in the Hemlock system with about 6000 hydrants.

High Pressure System

The Holly or high-pressure system installed in 1873 was an early application of the direct pumping into the mains without the use of a reservoir. This type of pump was originated by Mr. Birdsill Holly of Lockport, N. Y. about 1870, so that the Rochester installation was one of the pioneers in this type of supply. That it has been in continuous operation for over 50 years is sufficient proof of the wisdom of its adoption.

The equipment originally installed was a Holly quadruplex steam pumping engine, having a maximum capacity of 3,000,000 gallons per day; two Holly quadruplex pumping engines each having a daily capacity of 2,000,000 gallons and arranged so as to be operated either by water power from two turbines working under a head of 90 feet, or by steam power from an independent steam engine; also a pair of Holly rotary pumps with a daily capacity of 2,000,000 gallons, operated by a steam engine. Steam was supplied by three ordinary tubular boilers, 5 feet in diameter and 14 feet long. The water power was supplied by Brown's Race from the Genesee River; the pumps also obtain their suction supply from this race.

In 1904 the 3 old steam boilers were replaced by two Scotch Marine boilers of 250 H. P. each, and the old rotary pumps replaced by a centrifugal pump operated by a De Laval steam turbine. In 1906 an auxiliary station on South Water street was installed, equipped with a 3,000,000 gallon Worthington 10-inch, 3 stage, centrifugal pump, directly connected with a 275 H. P. G. E. induction motor. Suction supply is obtained from the Johnson and Seymour race, from the Genesee River, through a 10-inch steel pipe and also can be obtained from a 6-inch connection with the Hemlock system. In 1925

the 50-year old Holly pumps with the 20-year old additions at the Brown's Race pumping station were all replaced with four 3,000,000 gallon electric driven turbine pumping units.

The Holly system is used solely for fire purposes, pressure being maintained normally at 80 pounds by means of two Gould single-stage centrifugal pumps electrically operated, of 475 gallons per minute capacity. One of these units is operating continuously, drawing from a 12-inch Hemlock main under 52 pounds pressure and delivering at 80 pounds into the 20-inch Holly main. Upon the receipt of a fire alarm one or more of the electric turbines are started and the pressure raised to 135 pounds at which it is kept until the "fire out" signal is received. There are 25 miles of Holly mains, varying in size from 6 to 24 inches, mostly 12 inch, on which are installed 460 hydrants.

MAINTENANCE METHODS

Our repair department is up to date in every respect. It is equipped with all the modern devices for rapid and efficient maintenance work as well as taking care of a large share of the new construction work.

Our meter repair shop is complete with its devices for testing and repairing all sizes of meters. The plan of keeping a complete history and record of each meter from the date of its first installation is found to be of considerable service.

Rochester began the use of meters at the inception of its supply system, but only a small percentage of the services were metered up to 1902, when it was reported that one-third of the services were metered. We now have 58,000 services and all are metered except about 100 of the older fire services.

The water rates fixed at the beginning of our system prevailed generally for over 40 years, being increased about 25 per cent in 1921.

Our accounting system is on a modern basis, the meters being read in order continuously throughout the year and the consumers bills sent out promptly and regularly. The city is divided into 3 equal sections and the billing is done in rotation each month, so that there is no longer the great congestion at the end of each quarter, as formerly, when all the bills were delivered at once. The revenue of the water bureau is over $1,250,000 annually.

Rochester was a pioneer in the use of wrought iron pipe, Holly pumps and the long distance telephone, but there are two more items

in our practice on which we claim to be pioneers. The first is in the matter of records, for besides the usual records of rainfall, temperature, gauging, etc., which have been kept, from the beginning of the system, at the lakes and reservoirs, there was established in 1891 a system of taking evaporation records at Highland Reservoir which has been continued daily during the past 36 years.

For measuring the evaporation 2 indurated fiber tubs, about 15 inches in diameter and 6 inches deep are used. These are filled each day with a known quantity of water, one is placed in the water of the reservoir and one on the shore. After a certain interval, usually 24 hours, the tubs are removed and the amount of water remaining determined. The difference is the loss by evaporation. Our engineers have an ingenious formula for transposing ounces of water into inches of evaporation. Of course temperatures of air and water as well as rainfall, velocity and direction of wind are carefully observed at the same time, as these factors effect the final result. In winter, a special tub is used in the water only. As it is apt to freeze, it is weighed and replaced twice a day. The results of these observations are tabulated and published in the annual reports of the Engineering Department.

The other pioneer experiment to which I referred is the application of iodine to the water supply for the prevention of goiter. This was inaugurated at Rochester in the spring of 1923 by Beekman C. Little, then Superintendent of the Bureau of Water, and Dr. Geo. W. Goler, Health Officer of the city. The application is made twice a year, in the spring and fall, for a period of from 2 to 4 weeks. The sodium iodide is applied as the water enters Rush Reservoir, about 16 pounds being added daily for the first week and at longer intervals for the rest of the period. The application is made under the direction of the Health Officer of the city.

The operation and maintenance of the water works is vested in the Commissioner of Public Works, and the design and construction of new work under the City Engineer, both appointed by the Mayor. Prior to 1900 the water works was a separate department and the Chief Engineer was the sole authority on both operation and construction.

FUTURE SUPPLY

The total safe yield of our present watershed is estimated to be an average of 32 million gallons per day. Our average consumption

at present is about 28 million gallons daily and on certain days in the summer the consumption exceeds the average by several million gallons. The need for an additional supply has been seen for some time and surveys, gaugings and studies of the various possible sources have been under way for the past 5 or 6 years, culminating this year in the joint report of Allen Hazen, Harrison P. Eddy and Edwin A. Fisher on "A Future Supply of Water for the City of Rochester." This report recommends the utilization of Honeoye Lake, lying immediately east of the present sources of supply. This lake, while only about one-half the size of Hemlock, empties into the same outlet, Honeoye Creek. The proposed plan contemplates the erection of a dam at a narrow point in the outlet, where it flows through a deep cut between hills, thus creating a reservoir some 15 miles long and averaging three-fourths of a mile wide, having an area of about 8000 acres.

The water level of the present lake is to be raised about 30 feet, giving an available storage of about 45 billion gallons. The reservoir would intercept all of the water flowing from either Hemlock, Canadice or Honeoye Lakes, and would have a catchment area of about 187 square miles. The water is of the same quality as Hemlock, but should filtration become necessary, an ideal site is afforded just below the dam, where the water can flow to and from the filter beds by gravity. Two 60-inch conduits about 18 miles in length will be required to deliver the ultimate supply from this source. It is estimated that an additional 70 million gallons daily can be obtained, which, together with our present source, would give 100 million gallons daily, sufficient to last at the assumed rate of growth for at least 30 years or until the population served would equal one million.

Application to use this source has been made to the New York State Water Power and Control Commission. As considerable opposition developed at the public hearings held by the Commission, its decision is awaited with considerable interest by the citizens of Rochester.

MANAGEMENT OF A MUNICIPALLY OWNED WATER WORKS[1]

By Frederick W. Albert[2]

The maintenance and operation of a system of water works, handled as a purely business proposition, requires essentially a business management, not overlooking the purely technical or scientific considerations, which are necessarily a part of such a business. The questions involved do not relate solely to the sale of a commodity supplied in the form of a water service, but also deal with the quality of the water supplied and the design, construction and operation of the physical property, by and through which the service is rendered.

The subject as a whole is so broad, if treated in the detail each part and item deserves, that it would be impossible to compress the various elements into the brief space of this paper. Consequently, let us assume that the selection of a water supply has been properly handled, the plant built and equipped, and the mains and services laid, and limit the discussion to the sufficiently large problem of the management of a municipally owned water works as a going concern. This is after all the matter nearest our hearts, for very few, if any, of us ever get the opportunity to create such a system, but are given the task of taking over a plant often sadly run down at the heel, requiring our every energy and all of our ingenuity to pull it out of the "Slough of Despond" and onto "Firm Ground," by the exercise of all the arts and artifices employed in the management of the most successful modern business.

The Manual of American Water Works Practice, which is so full of detail and helpful information on other subjects, is pitiably silent on the all important question of management, even though one general section is given over to the subjects of "Financing and Management." In the section under this heading, financing is the only subject treated, leaving the question of management up in the air. In view of this,

[1] Presented before the Kentucky-Tennessee Section meeting, January 19, 1928.

[2] Engineer in Charge of Water Department, Knoxville, Tenn.

consideration of the fundamentals of business management may be profitable at this time.

WHAT DOES MANAGEMENT IMPLY?

Management implies three things—a force, a purpose or result to be obtained, and a director of this force toward the desired end. If any of these three things are omitted in any capacity, no such thing as management is possible. The most important thing about management is that it deals with forces—that is, energy, which have as their source, capital, labor and land. The manager or director must direct these forces. He cannot be tied to details of an office, department or organization. His special work is cut out for him by the forces which he handles and the objects which he must attain in their direction or management.

For many years it has been supposed that engineering had to do solely with intelligent development of that energy which depends upon fuel and a machine. Business men who are now analyzing their productive processes, find the profession of engineering has been extended to include development and control of that energy which displays itself through minds and bodies of men by the conservation of energy and the correlation of the forces or production.

A saving of energy formerly lost, or the institution of a frictionless organization may have other purposes than increase or maintenance of profits, but unless they bear upon the question of profits they should not be charged to productive management.

The manager who cannot organize a system of management without sacrificing permanent profits has not the faintest conception of the nature of his work. However, a thorough-going plan of management may, and for that matter generally does, involve the outlay of money which may not immediately show results. No one business policy has caused the wrecking of so many firms and the shattering of so many managerial reputations as that of paying dividends regardless of the means and sources of income.

Many managers have tried to short-circuit their forces of production to show such results, by putting the capital meant for production purposes into the dividends. This practice has proven fatal to many railroad developments in the past, and is no less fatal when applied to the business organization of a compnay.

Management, therefore, involves not only forces of production, but careful consideration of the results to be obtained—that is, the profits.

It is this latter purpose which distinguishes the men with managerial ability from the purely technical man.

No manager should assume that any conclusion he may reach is final. A rule of action may apply to the organization today, but higher planes of efficiency may render it obsolete by a new set of conditions and higher standards of accomplishment.

The principles of management hold true to every kind and branch of business. The methods of applying these principles are as varied as the types of business themselves. We might say that each business or each department has its own particular method which it has found would best fit it. Just as there are many styles of hats so are there many methods of management, and just as the best hat is determined by the fitness to serve the purposes of a hat, so likewise is that method of management best which carries with it the best functions of the department which it serves. The prime functions of management are "Control" and "Direction."

From the management point of view, the corporation is a form of specialization which puts the functions of ownership and policy control into the hands of a management different from that which directs the production operations of a business unit. A corporate organization forms one managerial unit made up of stockholders, directors, committees and officers, for the purpose of directing the financial policies of the business. The other division which is organized into a managerial unit is the operative or production end of the business. This latter has become further specialized into what may be called a Staff Organization and a Line Organization.

A corporate unit by exercising its function of ownership has delegated to itself the right of determining what shall be done by the general manager. A staff organization unit has become a necessary part of every business, because the general manager cannot know how everything can be done in the best way. The line organization gets its orders directly from the general manager, after advice received from the corporate and staff units.

As the duties of the general manager have grown it has become necessary to depend more and more upon the heads of departments to look after the details. These department heads not only have become executors of the work, but act as special advisors in the planning.

It has been said that 75 per cent of the enterprizes now in existence have no such thing as a chart or diagram showing the essential units

of which their organization is composed. An organization that cannot be charted so as to show a well defined relationship, cannot be said to be scientifically managed.

Every organization has four basic departments—they are financial, sales, production and record department. These units should remain distinct, but their efforts should be so coördinated as to bring about unified results.

The keynote of management is unity of purpose—working together in mutual dependence for a single result. The best organization is that which brings about the closest coöperation among the departments.

There are four principles underlying all organizations:

1. Management must have a head, be it one man or a formal planning department.
2. The organization must furnish necessary information to plan intelligently; they must get facts.
3. Each workman in each part of the organization must be given all conditions and facilities which he needs to carry on his work.
4. The workmen must be secured, trained and handled.

Organization is absolutely impersonal. Let no man become indispensable. Shape your men tc the organization and not your organization to the man. Let no man be able to become indispensable to the organization, and so by his absence, through sickness or intent, tie up the work. Understudies should be trained for every important position, even up to the head, so that the work can be carried on in any emergency.

A chart showing clearly the line of authority and responsibility of each individual in an organization will go far toward removing many interdepartmental jealousies. The chart should be so simple that it is self-explanatory upon investigation. Each man's position is thus made perfectly clear and he easily informs himself as to what course to take when transacting business with other departments. And here we have the beginning of our analysis of the management of a municipally owned water works.

THE ORGANIZATION

In the background and as the real force behind each municipal organization we have accountability to the electorate. Those of us who work in municipal organizations realize that each voter considers

himself a very large stockholder in the municipally owned plant. Because of numbers, it is impracticable for the electorate to exercise individual control, consequently it delegates this at election time to the councilmen, aldermen, or other candidates fulfilling the function and duties accorded these officials, or to the commissioners who have the department in charge. In the former, the councilmen then elect a mayor or city manager. This group of the electorate, council, mayor or city manager, comprise what is referred to in this paper as the corporate organization.

The first duty of the new head of the department is to familiarize himself with the records and operations of the department. Usually this takes considerable time, and necessitates first-hand investigation on the part of the new manager.

Diagrams or charts prepared as a result of these preliminary surveys will frequently develop the weak spots as well as the strong points in the organization.

He is now somewhat prepared to form a policy of procedure which, while designed to produce the desired end and the best results at the greatest economy in time, labor and cost, should be so framed as not to be accomplished at the sacrifice of his organization. In many instances, the end cannot be attained in a brief period and must consume months, and in some cases, years to effect the changes desired.

Having determined on his policy, as advised by his superiors or from his own knowledge of what is best, and having organized his department on paper, at least in the form of a chart, the manager is invariably confronted with the difficult problem of procuring suitable personnel with which to work.

There are very few cases on record where the department does not have within its organization a number of old employees who should be pensioned, having given practically their lives in work for the department, but whose methods or attitude are entirely out of step with the march of progress of today. These employees are protected either by civil service conditions, or by a sense of fairness on the part of the manager, who believes that they have a right to consideration and employment after so many years of continuous, faithful service. In either case, they cannot be summarily dismissed, but frequently have to be used by the manager in his endeavor to carry out his policy of reorganization and efficient operation.

Regardless of the disposition of these old, inefficient employees, the manager must conduct himself and the department, especially

in the early days of his office, in such a way as to develop respect, and a spirit of coöperation among the employees. No organization can live long, without the high cost of frequent labor turn-over, which does not possess these fundamental requirements of respect and coöperation.

Having selected his division heads (a process not without its hazards through political influences,—the traditional "it never has been done that way" and other elements) the manager now has begun on his organization.

With each division head he must carefully go over the operations peculiar to that division and obtain, if possible, from him, recommendations of organization and conduct of employees, as well as operating practices and conditions, which are not only scientific, but efficient, economical and satisfactory. The most successful manager will be able to draw recommendations out of his division heads which incorporate the manager's ideas, but allow the division head to feel that the thoughts and suggestions are his own. If this can be accomplished, the battle is half won, for the necessary action will then be taken with an energy and force otherwise impossible to develop.

These betterments often require the employment of experts not a part of the organization. The division charged with the reading, billing and collecting will more than likely need to have its entire system replaced to obtain the best results at the lowest cost. The employment, therefore, of specialists in this work will reduce the period of difficult transition, and smooth out the rough spots affecting the consumers, while at the same time the work is done at a reasonable cost. Such a re-birth is difficult under the best of conditions, and is especially high in potential trouble if the head of the division has old employees who have not had the training or experience to make the necessary revision, or if he has not the time to evolve the plans and steps required, while carrying on the normal activities of his division.

Similarly the engineer in charge of extension and construction may or may not be qualified to evolve plans for new structures and for the design of trunk and distribution mains, necessitating the employment of a consulting engineer whose business is along these lines. And so on throughout the department.

These professional experts, together with the director of law, director of finance, purchasing agent and other directors through whom the water department functions, comprise the staff organization of the water department.

The line organization consists of the heads of the divisions and other important officials actively engaged in the operations of the department. As stated above, the corporate organization consists of the electorate, the council and mayor, or city manager, through whom the head of the water department reports and from whom he receives indications of the policies he is to pursue and the results he is to attain.

While we are altogether influenced, and in many cases limited, by the policies enunciated by and through the city manager, and the corporate organization, and while we look to the staff organization for professional advice and solution of technical problems, it is with the line organization that we, as water works men, are principally concerned.

THE LINE ORGANIZATION

In the absence of precedent the line organization can be divided so as to show the operations and functions of the various divisions and personnel, beginning with the source of supply and ending with the accounts division. Following this idea, Division A in many plants would comprise both the filtration and pumping operation. In some, Division A would consist of operations incident to the source, and supply, and Division B, to those comprising the discharge of the product into the Distribution System. Division C would logically incorporate the engineering operations, dealing with the work in the field. Related with this work would be Division D, which is Stores and Division E which would be Construction. Division F, Reading, Billing and Collecting, while Division G covers Accounts.

In Knoxville, Tennessee, we have combined Divisions A and B, or Pumping and Filtration; Divisions C and E, Engineering and Construction; Divisions D and G, Stores and Accounts, leaving Division F, Reading, Billing and Collecting the only single Unit.

This obviously decreases the over-head through elimination of supervising personnel, and because of the limited size of the plant, permits consolidation and concentration of effort.

The duty of the head of each division, under the direction of the manager, called either the superintendent, the engineer in charge, or some similar title, is to select and train competent, skilled, efficient personnel to the end that the department will operate as efficiently and economically as any private concern doing business of equal magnitude. This is highly essential as the favorite pastime of the

electorate is to make comparisons, with or without foundation, but always tending to show that the management and administration of the municipal water works is extravagant, inefficient, and generally calling for the discharge of those in charge, and proposing the substitution frequently of men entirely untrained and unskilled in the work.

Thanks to the inheritance of old employees from previous administrations, not necessarily imbued with the highest of ideals of public service, protected as these employees are, either by civil service, or by length of service, the experienced manager and division heads under him will establish early the policy of attempting to use the personnel at hand until it proves unsatisfactory, for the very good reason that, first, it is good business to utilize the experience of these long in the service, their knowledge and understanding of local conditions, as well as their knowledge of the properties of the department, and second, because labor turn-over is very expensive.

If the personnel once appreciates that the manager is reasonable, fair and honest, and intends to give everyone a chance, there will be little trouble in developing the beginnings of an esprit de corps, loyalty and lasting morale, which are the foundations upon which his success as a manager must be built.

In order to be successful, the manager and division heads must earn the confidence of their assistants and associates, for without this, they can never develop and get the coöperation from them which is necessary. Scientific policies, marvelous organization plans and high ideals will go for naught, without the wholehearted coöperation of the personnel under the manager and division heads. In view of this, it is desirable that the division heads carefully study the operations expected of each individual, and then after a detailed survey of the personnel, assign those best fitted to the task in hand. The policy of equal pay for equal work should be early established. The very thought of favoritism should be eliminated from all consideration and the general practice of advancement through the ranks should not only be promulgated, but adhered to. This, however, should not handicap the manager or division heads under him from employing men outside of the organization, either in or out of the city, to fill key or other important positions, if a careful study, a reasonable trial and a detailed analysis of the personnel in hand convinces the manager that such employment is for the best interests of the department and city.

Having not only organized his department on paper, but having

now completed his organization through selection of the best available personnel, the manager and division heads should begin the development of understudies, or substitutes for all positions of importance.

It is entirely essential that no person should at any time get the idea that he or his position is indispensable to the successful operation of the department. Probably each of you have had experience along these lines, as it frequently centers around old foremen and old men at the pumping station and filtration plants. There are many cases on record of foremen who have purposely carried the distribution system and its valve operations in their head, with the intent of controlling the operations of the department through their employment, under such conditions as they may wish to impose.

Before leaving the question of personnel, the manager and his division heads, particularly if they are segregated from the rest of the city forces, will consider the question of hours and time. Insofar as practicable, he should prescribe the standards in practice in private industries in his community. He should neither set up factory hours, nor banking hours, but should take for his standard the hours of similar utilities operating in his community. If this standard throws his hours out of line with those observed by the other city forces, then the question should be discussed in detail with the city manager and other directors, but, above everything else, he should endeavor to learn and put into practice, the policy of uniform hours, and equal pay for the same service, not only in his own department, but if possible, as it is affected by the operations of the other city departments.

Co-incident with his study of the personnel the manager, and division heads, should consider the question of tools and equipment with which the personnel are to produce the results and attain the end desired. The experienced manager needs only an opportunity to enable him to select the essential, modern, up-to-date tools and equipment designed to justify their cost and return to the department and the corporate organization, more than $1.00 in result for $1.00 spent.

Many municipal water works are and will be for years to come, saddled with old, antiquated pumping stations. This fact should not prevent the manager from encouraging the recomendation that cost-reducing equipment be obtained, and in seeing that its purchase, with or without encouragement from the division head, is made. These devices range in importance and cost from proper firing

mechanism to gauges and charts which if properly analyzed and used will enable the operator and his division head to show a tremendous saving, not only in coal, but in other supplies used in and around the pumping station and filter plant. Besides the usual pressure gauges, the station should be equipped with recording gauges for steam and water pressure, CO_2 and flue gases, and proper scales for coal, ash and feed water.

ENGINEERING AND CONSTRUCTION UNIT

The same thought applies to the operation of the Engineering and Construction Division, which probably has been run with a total disregard for the need of accurate records, organized and scientific installation of mains, valves and fire hydrants, and their maintenance and upkeep. Here more money can be wasted through the purchase of unnecessary equipment than can possibly be saved, over a long period of time, unless the manager knows, and with the Division Head, can determine where to buy and where to cut.

Regardless of what he cuts, he must equip this division with such cost-saving and labor-saving devices as wireless pipe finders, geophone, valve finders, recording pressure gauges, pitometers, surveying instruments, tapes, stakes, etc., and if the work is of such magnitude as to justify the expedinture, he should purchase motor transportation in order that not only the engineers, but labor personnel can be moved from job to job, with the lowest possible waste of time.

If his records are analyzed, the manager will learn early that it costs a great deal of money in waste and loss of time to move a crew, unless he so organizes his work as to effect the maximum use of his transportation, and thus eliminate the unproductive waste of idle hours and half-hours, which quickly run into figures.

Depending upon the magnitude of the extension programs, the manager will determine on the wisdom of purchasing motorized air compressors, including tools such as caulking, drilling, spading and tamping; one or more trenching machines, designed for municipal operations; backfillers; dump trucks; and other motor transportation; pipe cutters and regular lead or leadite melting pots, as well as the ever present picks, shovels, hammers and other ditch tools. The manager may find that the economical operation of his department will require the purchase of an acetylene welding and cutting outfit and the operation of his own blacksmithing shop.

His purchase of such equipment can only be made after the man-

ager has analyzed the local labor and contracting conditions, and has determined beyond a shadow of a doubt, that he can do the work at a lower cost to the city, than if let to a contractor.

HANDLING OF SUPPLIES

Handling of stores should call for the most careful study, as all too often there is loss to the department in the holding up of work due to failure of stores to be delivered on the job at the proper time, and in the "disappearance" of stock, which often takes place. To eliminate this loss and effect the saving which he has a right to demand, the manager should require the issuance of stores on requisitions placed in the hands of the store-keeper in sufficient time to permit delivery to be made before the materials are actually required. This will necessitate proper stores-keeping records, preferably in the form of cards showing the maximum and minimum quantities to be carried in stock, automatically coming out for requisition of additional materials when the stock reaches the minimum.

In the vast majority of municipally owned water works, under the city manager plan of city government, all purchases not only for the rest of the departments of the city government, but also for the water department, are and properly should be made through a city purchasing agent. Requisitions from the manager of the water department to the city purchasing agent should be made in sufficient volume to take care of not less than three, and preferably six months operations, but in any event, in sufficient volume to obtain the lowest unit cost.

Unfortunately, most city purchasing agents are imbued with the ever present idea of the lowest price, with the result that unless the manager can get the support of the city manager, he may be faced with the extravagant situation where he is called upon to use the lowest priced article regardless of the economy involved through adaptability, use, durability and the other elements which in the final analysis determine the lowest true cost. The manager will likewise encounter a disinclination on the part of most city purchasing agents to buy the equipment which the manager's training and judgment dictate he should specify. His tact and diplomacy will early be brought into use in his endeavor to get what he knows he should have, over the purchasing agent's insistence that price is the sole basis on which all purchases will be made.

Frequently the manager, by placing requisitions for larger quanti-

ties, sometimes even yearly requirements, can effect savings not only through logical competition, but by including deliveries at times and places specified by the manager. There are many tricks of the trade similar to this which the manager can employ to bring about the savings which show not only economy, but efficient business management, not the least of which is in proper handling of his scrap pile.

It is surprising the number of dollars which are thrown away by unthinking operators through disregard of the proper collection and segregation as well as the sale of scrap, through competitive bidding. One instance is sufficient. Most alum used in filtration work is delivered in bags. Through investigation it was early found that good alum bags could be resold to local consumers at prices which made the handling of this salvaged material quite profitable.

But scrap is not the only source of "hidden" income. The manager who has the interest of his department closely at heart, will discover that often he can earn a "pretty penny" for the city by salvaging materials heretofore left in the ground. This requires figuring, for if recovery costs are greater than the initial cost, obviously he should leave the pipe and fittings in the ground.

READING, BILLING AND COLLECTING

In the Reading, Billing and Collecting Division, the tools and equipment needed for efficient and economical operation of this division, can be generalized under the heading of system, for in this division more than in the others, system counts.

After evolving a satisfactory, economical system of reading, billing and collecting, the manager will find that economy is greatly increased through the purchase of addressograph, billing and adding machines, providing the unit cost per account handled monthly is low enough. This is determined, of course, by the number of accounts on the books.

This brings us then to the question of records. Many authorities believe that this unit of the work should be handled by a separate division. Such a policy may be satisfactorily followed in large organizations like the national life insurance companies, but in municipal water works experience and practice has shown that each division is best equipped to maintain its own records. Obviously, it is the duty of the manager and his line organization to see that no records are duplicated.

PUMPING AND FILTRATION DIVISIONS

The pumping and filtration divisions in Knoxville, Tenn., are responsible for the supply, treatment, filtration and purity of the city water, as well as for all pumping operations incident thereto from the intake to the consumer. It has further the maintenance and care of all buildings and grounds used by the water department for plant and structure purposes. It also has charge of the operation, repair and maintenance of all reservoirs and standpipes; and collects, analyzes and files all records and data incident to these operations. The various charts from the reservoirs, and in the pumping station and filtration plant, are daily collected, carefully gone over by the technical assistant to the superintendent of the pumping station and filtration plant, and the day's operations planned as a result of this study, in conjunction with the report on future weather conditions, the season of the year, etc.

The division of engineering and construction prepares all projects for water main, valve and fire hydrant installation, maintenance or replacement; assigns this work to the various crews under the direction of the general foremen; follows up the actual installation to see that the map, card and field book records show the conditions as they actually are in the ground; makes pitometer and rate of flow surveys of water through the pipe in the distribution system, to show the carrying capacity of the various mains, and the requirements of trunk and feeder mains into the various sections of the city; organizes and directs fire hydrant and valve surveys to insure proper and satisfactory operation of these essential elements in the distribution system, as well as their existence, by posting map and card records in the office.

Division D and G, Stores and Accounts, receives and issues on requisition all materials and equipment used by all divisions; keeps card records showing a perpetual inventory of all stock; makes a monthly inventory of materials on hand and accounts for the distribution and consumption of stores to the end that the stores account balances each month; and is responsible for the preparation of all financial statements and records dealing with the operations of the Department.

Division F, Reading, Billing and Collecting, is variously known as chief clerk's office, office of the water department, water registrar's office, or by one of a dozen or more other titles. This division keeps all records showing installation of service connections, not only pri-

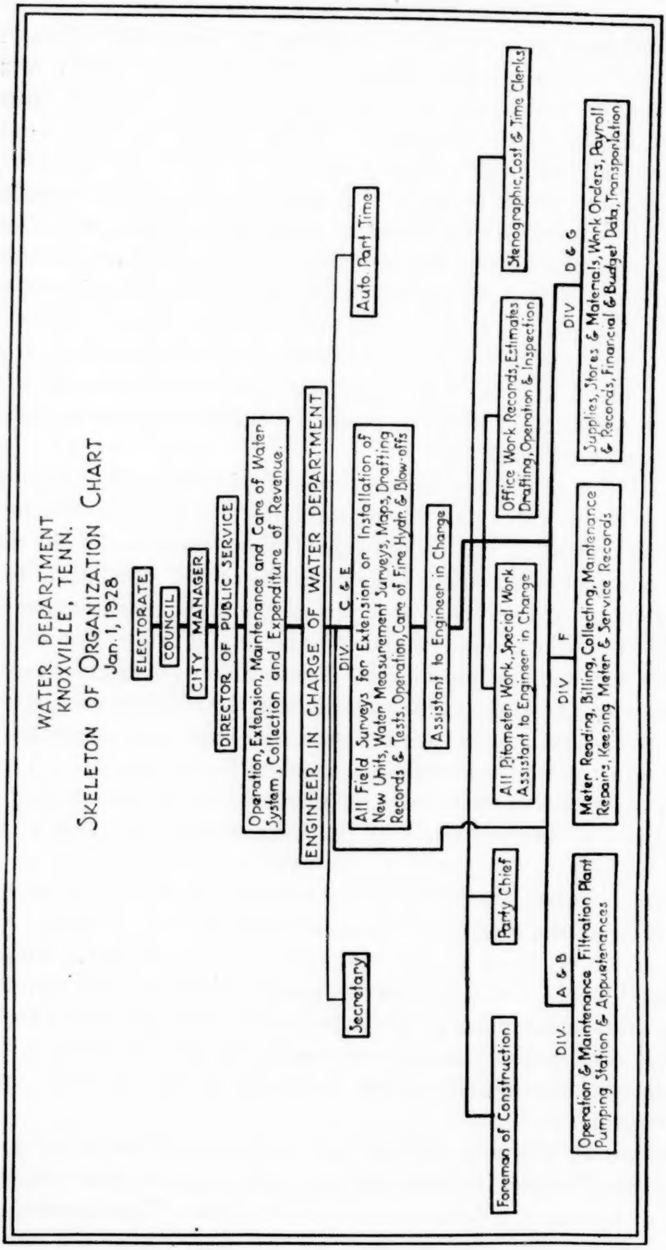

WATER DEPARTMENT
KNOXVILLE, TENN.
SKELETON OF ORGANIZATION CHART
Jan. 1, 1928
ELECTORATE
COUNCIL
CITY MANAGER
DIRECTOR OF PUBLIC SERVICE
Operation, Extension, Maintenance and Care of Water System, Collection and Expenditure of Revenue.
ENGINEER IN CHARGE OF WATER DEPARTMENT
Secretary
Auto. Part Time
DIV. C & E
All Field Surveys for Extension or Installation of New Units, Water Measurement Surveys, Maps, Drafting Records & Tests. Operation, Care of Fire Hydr. & Blow-offs
Assistant to Engineer in Charge
Foreman of Construction
Party Chief
All Pitometer Work, Special Work Assistant to Engineer in Charge
Office Work Records, Estimates Drafting, Operation & Inspection
Stenographic, Cost & Time Clerks
DIV. A & B
Operation & Maintenance Filtration Plant Pumping Station & Appurtenances
DIV. F
Meter Reading, Billing, Collecting, Maintenance Repairs, Keeping Meter & Service Records
DIV. D & G
Supplies, Stores & Materials, Work Orders, Payroll & Records, Financial & Budget Data, Transportation

FIG. 1

vate, but industrial and fire; of complaints and leaks; installations of all meters, their condition and maintenance; all applications for water service connections and monthly reads, bills and collects on the water consumed each month on each service, in accordance with the rates, rules and regulations of the department. It likewise is responsible for the repair of all leaks on service lines, the repair of all meters and makes all inspections of matters affecting the water consumer.

It is obvious that this mass of records dealing with the different subjects and different operations could not be satisfactorily kept and maintained by one central division without additional, and in my judgment, unnecessary personnel.

In addition, each division head has constantly at his hands the necessary data and information required to make a complete and comprehensive report on the operations of his division each month. These reports are due on the desk of the engineer in charge on the tenth of the following month, and enable each division head, as well as the engineer in charge, to prepare his annual statement of the operations of the department at an early date after the end of the fiscal year.

Through a study of the organization chart of the water department of Knoxville, shown in figure 1, it may be readily seen that the personnel needed in the management of a business collecting and spending $600,000.00 per year, is not very large, and there are no duplications.

THE BUDGET

While the budgeting of the department is really an incident and determines the personnel organization, consideration of the budget as a necessary element in the management must be treated as a separate proposition.

In all water departments under the city manager form of government, and in many under other forms of municipal government, the manager is called upon to furnish his superior officer, prior to the closing of the fiscal year, a statement of his anticipated revenue under the existing rates, rules and regulations, for the ensuing year, together with plans for the expenditure of this revenue.

A vast majority of the municipally owned water works are self sustaining and by charter, or law, are obliged to live within their yearly income, while at the same time their revenue is not available

for any other purpose or function of the city government. In some cases, however, this is not true, and the municipal water works is permitted, through the council, to float bonds covering various projects, or the water rates are so manipulated by the council as to provide additional source of revenue for some other department of the city government.

Considering then the majority, where a municipally owned water works lives within its revenue, the budgeting of the revenue and expenditures, as they apply to the coming year, is a very important duty.

The operating expense such as pumping and filtration costs, and reading, billing and collecting costs, together with the sinking fund and interest on floated or funded debt, are largely fixed charges. The remainder of the revenue is then available for extension and construction work, engineering, stores, and the accounting, incident thereto.

If the previous administration has made a pretense of keeping cost records, the manager is in a fair way to make an intelligent estimate as to the work he can do. If, however, these records are not available, his first budget at least, is largely a guess.

Under these conditions, one of his first duties, insofar as practicable and advisable, in view of the cost entailed, is to develop, establish and incorporate a small and satisfactory cost-finding and keeping system. Without a great deal of expense the fundamentals can be developed and in a short period of time, the manager can know in a rough way, at least, what it actually costs to prepare and pump 1000 gallons of water,—what it costs to read, bill and collect the average account, as well as what it costs per foot for making water main installations, replacements, lowering and repairing, and the same information for valves and fire hydrants.

This information is particularly important as it applies to such work as has been, or may be done under contract, for one of the earliest arguments the manager will find himself engaged in is in proving that a municipally owned water works can do its own construction work as cheaply, and possibly more cheaply, than if it is let by contract. Of course, this is impossible if the tools and equipment in the hands of the manager are antiquated, inefficient or obsolete, for his activities must be based on the current practice of contractors and his tools and equipment must be on a parity with theirs.

Under the terms of its charter, a municipally owned water works

must live within its current revenue and under no conditions is it permitted to create a deficit. It may accumulate a surplus for its own future needs, but if these are not approved by the corporate organization, then and only then should the surplus be used as a basis for a reduction in water rates.

The time comes, if the department has lived not only within, but up to its yearly revenue, when major extensions, improvements or betterments, must be made. These should be taken care of preferably through the establishment of a reserve, if the rates, rules and regulations will provide a surplus or if there can be reasonable assurance that such a reserve will be retained for the object it has been established to attain. If the rates will not permit of such a reserve, then the manager, through the city manager and the council, must either increase the rates or float a bond issue to provide funds for such betterments.

Assuming the ideal when the department has developed, as a result of efficient, scientific management, its distribution system to a point where it will take care of not only the present, but of reasonable future needs, and assuming that the headquarters, as well as the pumping station and filtration plant, reservoirs, and other property, including trucks and equipment are in such condition that they will be good for present and future operations, and finally, where no reserve is needed, at such time and only then should the department declare a dividend and show its profits through a reduction of rates.

This day can be hastened if the department has been protected by law or ordinance against the uneconomical and unscientific practice of providing free water or free service to any consumer, including the city.

The rule has become more and more general, first, that there shall be no free water or free service to individuals, industries or other users of water, and, second, that the city shall pay for water used for municipal purposes, including fire, street flushing, sewer flushing, hospitals, schools, jails, etc. and shall also pay a legitimate fire hydrant rental, and a fixed charge on miles of water mains 6 inches and larger in diameter. In other words, if the department receives pay for its services and in turn pays public utility taxes to the city, county and state, it has a right to demand of the taxpayers this return for the services it renders the city.

If these payments are actually made, as they are to privately owned plants, the profits and dividends which the municipally owned

plant can declare to its stockholders—the water consumers—in the form of reduced rates, would be far more frequent and larger than they are now.

EXTERNAL CONTACTS

A duty of the manager, which is of equal importance to his organization of the water department is his obligation so to direct and conduct the affairs of his department that the relationships between the water department and the other city departments will be congenial, coöperative and mutually beneficial, for, after all, personnel comprising the city government is employed and paid for the sole purpose of providing and giving to the inhabitants of the city, the best service at the lowest practicable cost.

Frequently, the manager will find that the city already owns and operates a municipal garage where other city transportation is stored and serviced. Often, after the development of a mutual sense of obligation and desire to coöperate, he will find that he can save much money by storing and maintaining his motor transportation along with the other city owned vehicles in the municipal garage. The success of such a movement, of course, depends entirely upon the intent of the superintendent of the municipal garage to treat each car and each department alike. Without that spirit, favoritism will early creep in and the water department will either profit cr suffer, according to the influence and pressure which the manager or some other department director can bring to bear upon the garage officials.

Usually the health department in its desire to create the best possible conditions leading to the good health of the citizens will make recommendations or demands on the water department which are extravagant and ill advised. The primary duty of the manager of the water department, is to coöperate with the health department and provide, wherever logical and practicable, all extensions considered necessary for the public health by the health department. This situation will generally exist and the manager will seldom find it necessary to argue against the recommendations of the health department excepting in abnormal and unusual cases.

The same applies to the fire department where the demands for additional fire hydrants, or mains of larger capacity to take care of unusual hazards are considered necessary by that department.

The service, street and sewer departments are usually found to be sources of greatest complaint by the water department through the

unintelligent operation of fire hydrants and other connections through which these departments get water for their activities.

Ordinarily the supplies for schools and other departments operating in buildings, go through meters and are recorded and charged for in the course of the regular business of the water department.

It is obvious that these external contacts are with departments having fully as important functions as the water department and make life pleasant or otherwise, according to the spirit developed between the personnel. Consequently, tact, diplomacy and insistent requirement that his own associates shall so conduct themselves as to early develop good-will and coöperation through their contacts with the other departments is one of the most important duties of the manager.

The same thought applies to the other public utilities. The power, gas, light, telephone and street-car companies are all in a position to help and frequently are all very anxious to help, if the personnel of the water department will only meet them half way. It is not a question of favoritism, or special privilege, but more generally a desire to live and let live and to help in time of need.

The experienced water works manager knows that many times in the year, as the result of emergencies, the goodwill of someone of the other public utilities is essential to the continuous and satisfactory operation of the water department. The golden rule is a splendid motto to post, and a splendid ideal to attempt to live up to, for the manager who will "do unto the others as he would be done by" will get along much farther and much happier than the manager who follows the principle of "doing the other fellow before he does you."

THE GOOD WILL OF THE PUBLIC

In a sense all of the foregoing practices and principles set forth in this paper are only preliminary to the most difficult task which confronts the manager, namely, developing and holding the good will of the public.

In 90 per cent of the cases, water consumers are called upon to pay either electric, gas or telephone bills. In the vast majority of these cases anyone or all of these bills is continuously in excess of the consumer's water bill. However, the consumer realizes that the other public utilities have to purchase their product in one way or another, while he contends the municipally owned water works gets its product for nothing. Consumers never stop to think or understand that it

costs money to locate sources of supply, to build structures and equip plants required to obtain, treat, purify and pump this supply or that it costs a great deal of money to deliver the water supply to the consumer's front door. These costs are greatly in excess of the cost of the product of the other public utilities, but the consumer has only one thought in mind, that water and air, the essentials of life, were God-given and that water should be as free as air.

The fundamental objection to paying for water must be explained away and the consumer made to realize that the water department is not operated for a profit, but at cost, bearing in mind the maintenance and extensions necessary to take care of the future growth of the city.

Many objections and much of the public criticism of the department can be eliminated if the manager will insist that all communications from the public, whether verbal or written, be handled intelligently and as speedily as would be the case in any private business. After all, the water consumer is fairly reasonable and will be satisfied with an intelligent and serious reply, no matter how trivial his complaint or request.

Much good will can likewise be engendered by the proper use by department employees of the telephone. No greater source of misunderstanding has been invented than the telephone and consequently, patience and intense desire to be of service, help and develop good feeling toward the department must be deep rooted in the minds of all department employees coming in contact with the public over the telephone.

Experience has inclined many executives to the belief that women, neither too old nor too young, are best equipped by nature to handle this peculiar type of work, and their employment in these positions is becoming more and more general.

Most water departments control the payment of water accounts through the practice of shutting off the water in case of non-payment. Here again, even though the consumer knows that he is entirely at fault, his favorite indoor sport is in blackguarding the water department because his water has been cut off.

The selection of men employed to collect delinquent accounts, make inspection as to cause of high bills, and turn-on and off water service is of primary importance, and is but another example of where the man must be selected for the job, and not the job created for the man.

Complete understanding, coöperation and good will of the other departments in the city government, the other public utilities, and the public as a whole, is of utmost importance to the successful management of a water works. Without this, the technical and administrative success of an executive or manager, no matter how outstanding that may be, goes for naught.

The management of a municipally owned water works is no sinecure. The position demands the possession in one individual of many rare qualifications, traits and characteristics. The happy possessor of all of these, who is still in the water works game is there because of his love of the game, and his desire to serve. There can be no other reason for his continuance in office, for the salary compensation is never commensurate with what he could earn in some other line of business. In spite of all this, there are very few of us who are charged with the operation of a municipally owned water works, who would be happy in any other service.

REFERENCES

Office Administration of City Water Department. Journal of American Water Works Association, April, 1926, vol. 15, no. 4, page 349.

Modern Business, Organization and Management. Alexander Hamilton Institute Series.

Municipal Government and Administration. By Munro.

PITOMETER ANALYSIS OF DISTRIBUTION SYSTEM FLOW[1]

By P. J. Hurtgen[2]

In recent years many of the cities of our state have passed zoning ordinances in order to provide a plan that will guarantee an orderly development of the cities and provide areas of sufficient capacity for residential, commercial and industrial development. The establishment of definite areas for the various classes of development has made it possible for municipalities to plan water-works distribution systems and trunk line sewers for the future with a reasonable degree of accuracy. The City of Kenosha passed a zoning ordinance in 1924, and has since carried out all of the development plans, based on the plans outlined in this ordinance. With this plan as a guide we deemed it advisable to have a survey made of our water-works distribution system in order to determine the adequacy of our present system and our requirements 25 years hence.

About a year ago the Kenosha Water Department had a complete survey made of the entire distribution system in order to determine whether or not the plan of construction that was being followed, with special reference to the capacity of the water mains, was an adequate and economical plan. In 1924 the Pitometer Company made a survey of our system to determine whether or not water was being wasted through leaky mains and services from which the city procured no revenue. In 1926 they were again called in to make a survey of our distribution system. Based on this survey, plans were recommended for a construction program for the next 25 years. The study made by their engineers was a comprehensive one and may be outlined under the following items:

1. A study of the probable increase in population during the next 25 years both in the city as a whole and in various sections. Studies of the probable location and growth of industrial districts.

2. A study of the present water consumption and fire protection requirements in various sections of the city and a determination of

[1] Presented before the Wisconsin Section meeting, October 14, 1927.

[2] Commission of Public Works, Kenosha, Wis.

the probable water consumption and fire protection requirements 25 years hence.

3. Investigations to determine the loss of head and coefficients of friction in trunk mains. Investigations of such points in the distribution system where present facilities appeared to be inadequate, to determine if replacements, extensions or cleaning of the mains are necessary.

4. Design and general details for reinforcing mains necessary to meet present needs and future requirements.

5. General plans and recommendations for an economical program of construction.

POPULATION INCREASE

Based on the past growth of the city covering a period of years, a population chart was prepared and the population curve covering that period was projected to cover the period 25 years hence. By using the school census, voting statistics, meter records and a study of the zoning ordinances, an independent determination was made of the present and probable future populations of each of the twelve wards separately. The estimated population of the city taken by wards differed by only 1,000 from the figure shown by the population curve for the entire city. The rate of growth in population of each ward was based on the school census. A study was made of each ward separately to determine the type of development permitted under the zone ordinance, giving consideration to residential, industrial and mercantile development and areas in which apartment house construction might be carried on. Consideration was also given to areas set aside for park purposes.

WATER REQUIREMENTS, PRESENT AND PROBABLE FUTURE

A number of years ago I prepared a chart showing our yearly pumpage from 1896 to the present time. Based on this chart, the Pitometer Company made a new chart showing the average daily pumpage for that period, together with their predictions for future consumption.

We have two 24 inch mains leading from the pumping station through which all of the water is pumped. One main supplies the north and the northwest portion of the city, and the other leads to the down town and south and west sections of the city. Pitometers were placed on each of these mains to measure the total consumption

for 24 hours, the night rate and the maximum for one hour. The industrial consumption, based on meter readings, was then deducted from the total to determine the domestic consumption and water used from fire hydrants. Based on our population at the time our survey was made, our total consumption was 107 gallons per capita per day. The domestic consumption was 56 gallons per capita per day. From the pumpage records and meter readings for the entire year, 1926, the total consumption per capita was 104 and the domestic consumption 62 gallons. In the estimate for future domestic consumption 60 gallons per capita were used. For future consumption the industrial and domestic use were plotted separately and the two combined to arrive at the total consumption. In order to determine the increase in industrial use the total consumption was plotted for nine of the largest plants, covering water consumption for six years, which was used as a guide for determining the industrial consumption. To this was added an amount estimated to take care of new industries. The total estimated consumption of the industries plus the domestic consumption gave the total probable consumption. The domestic consumption was arrived at by multiplying the estimated population in 1951 by 60, which figure represents the domestic per capita consumption per day. The result of this computation gave a total water consumption in 1951 of 103 gallons per capita.

In addition to these studies, and as a basis of comparison, studies were made of each ward separately, to determine the present consumption in each ward. In making these measurements, the flow was measured by means of pitometers set up on one or more of the main lines feeding that section. All other mains were valved off at the ward lines. The industrial consumption was arrived at by reading the meters on all of the industrial plants, laundries, hotels, dairies and public buildings at the beginning and end of the test 24 hours later.

The following excerpts taken from the report of the engineers will give a clearer idea of the method used in calculating the consumption for each district:

Wards 3 and 4

This section includes the business districts, several large factories, and one of the best residential districts. At the time of measurement, the industrial consumption was 441,000 gallons per day. By using the past growth of the Simmons Company as a guide we have estimated the increase in industrial consumption as 40 per cent for the twenty-five year period.

140 per cent of 441,000	628,000	G.P.D. Industrial
1951 estimated population is 17,000 17,000 × 60	1,020,000	G.P.D. Domestic
	1,648,000	G.P.D. Average daily consumption in 1951
Add 50 per cent for summer rate	824,000	
	2,472,000	
Add 50 per cent for maximum hour	1,236,000	
	3,708,000	G.P.D. Maximum consumption in 1951

This method was employed in arriving at the 1951 consumption for each ward, except that the rate of industrial increase in consumption differed in the various wards because of differences in zoning ordinance regulations.

The estimate of total consumption for 1951, taking each ward separately, was 25,457,000, as compared with 24,975,000 gallons as shown on the projected chart considering the city as a whole.

DETERMINATION OF LOSS OF HEAD AND INVESTIGATION OF WEAK POINTS IN THE DISTRIBUTION SYSTEM

A study was made of the distribution system to determine the amount of frictional resistance in the present supply mains. The main trunk lines were used for this test, and gauges which could be read to 0.5 foot of head were used. Losses of head were procured in tenths of a foot by taking simultaneous readings at each end of a section of main. These readings were averaged over a considerable period of time. While the gauges were in operation all side feeds were valved off, and a pitometer was used on the main to measure the flow. These tests were made on stretches of pipe that served only small consumers in order to eliminate as much as possible losses from domestic consumption. The result of these tests showed that our water mains were not corroded to any appreciable extent. The coefficient for a new pipe and pipe in use only a few years usually averages from 130 to 100. The coefficient on our pipe ranged from 99 to 135.

Investigation of the weak points in the distribution system was made by taking 24 hour gaugings of the flow at critical points on the

large mains. Pressures were obtained by test gauges fitted into a hydrant cap and attached to the hydrants. These pressures were recorded and low pressure areas noted on the map. The next step in the location of weak points was the gauging for 24 hours of the flow in the trunk mains, to determine the velocity of flow in feet per second. These tests were made with all valves open in order to get the flow under normal conditions. The result of these tests showed that the north 24 inch feed main carried about 50 per cent more water than the south 24 inch feed main, notwithstanding the fact that the largest consumption lay south of the plant.

Another fact brought out in this survey was the condition of flow on a certain street on which the flow in a 6 inch main was toward the pumping station instead of the opposite direction. This was due to the fact that a number of large meters on this line were supplying water to one of our largest factories.

DESIGN OF MAINS FOR PRESENT AND FUTURE

From these surveys the weak points in the distribution system were disclosed and data procured for the consideration, design and location of reinforcing mains to meet these requirements.

The first consideration was given to the two 24 inch mains leading from the pumping station. During the year 1926 the maximum pumpage for one hour reached the rate of nearly 16,000,000 gallons per day. The Fire Underwriters require that provision be made for two fires, one in the high value section requiring 5500 gallons per minute, and another in an outlying section requiring 1500 to 2500 gallons per minute. Seventy-five hundred per minute or 10,800,000 gallons per day, therefore, were considered adequate for fire purposes. This amount added to the 16,000,000 amounted to 26,800,000 gallons per day or a velocity of 6.6 feet per second for these two mains. This was considered high, but because of the fact that the mains were short in length and high in coefficients this was considered satisfactory for the present.

As stated before, the estimated rate of consumption for 1951 was about 25,000,000 gallons per day. Adding to this the fire requirements of 10,800,000 gallons the maximum demand for that year was found to be 35,800,000 gallons per day. This would give a velocity of 8.8 feet per second in the two 24 inch mains, which would mean a loss in the head of about 16 pounds. While the velocity is close to the limit of the capacity of the mains, the short distance to the heart

of the business district makes the velocity allowable. The capacity of these 24 inch mains was considered ample for the next 25 years.

Similar consideration was given to each district covered by the survey. Separate calculations were made for the requirements for each district, usually composed of two wards, and additional mains were recommended of such sizes consistent with proper velocities as would supply the district under consideration.

In addition to the report submitted in connection with this survey the Pitometer Company submitted maps on which the sizes of mains recommended for the entire city and the territory contiguous to the city were noted. We are confident that these recommendations will be adequate to take care of our requirements for 25 years hence. A construction program in five year cycles to be followed in the order of their importance was also outlined in the report.

While many of the recommendations outlined in their report were anticipated by the department, we are confident that the result of the study will save the department many times the cost of the survey, in that we have a definite plan to follow for future extensions to the distribution system.

GROUND WATER LEVELS IN INDIANA[1]

By Charles Brossman[2]

The matter of ground water levels is important to Indiana as a large percentage of municipalities are able to get water only from underground sources.

About seventeen years ago I made a study and tabulation of such conditions and then found there had been considerable drop in water well levels throughout the state, running all the way from a 3-foot drop in eight and one-half years to as high as a 40-foot drop in ten years or, in other words, a drop of almost 3 feet per year in some cases.

There is no question that these drops have occurred, but there is considerable question in my mind whether such drops are reflected over the entire area of the state. These drops may be more local in their character and an analysis of some of these wells would indicate this is the case. For instance, in 1917 information from Kentland showed a drop of 48 feet in five years. A few years later I was called to Kentland to put in a new well. Investigation shows that the original well was a deep gas well, about 1300 feet deep. A new well was placed in this same district, but was only drilled to a depth of 90 feet to the rock, the well being in fine lake sand. This well has held up to date about the same as originally.

A similar condition holds for Remington where they had a well approximately 500 feet deep, showing a drop of 8 feet in ten years for the year 1917. A few years ago the writer placed a new deep well and pump in this same town and the record today shows no drop during the past few years for the new well. The same would probably hold for other places.

Questionnaires as to the cause of any lowering of the ground water are at variance and I believe there are many localized recessions where the draw has been increased on the same wells that have been in for a number of years. This would show its maximum, at the well, as might be expected, and would probably show less and less effect as the distance from the well was increased. I do not question

[1] Presented before the Chicago Convention, June 9, 1927.

[2] Consulting Engineer, Indianapolis, Ind.

that there has been a lowering of the ground water in past years. It is hard to conceive that with the drainage ditches built and thousands of miles of drain tile manufactured each year, providing such a rapid runoff from the farms, it would not have some effect on the upper levels of the ground water.

Undoubtedly certain localities have reason to believe that there is a recession of ground waters, and drainage no doubt has had some effect on lowering this level. It should be remembered that in many places where wells show a decrease in levels there has been an increase in population and a corresponding increase in water consumption which would cause an extra draft upon the wells. The investigation also shows that in some places where the consumption has not varied greatly there has been some decrease in the water level.

Farm drainage, dredging and deforestation would, no doubt, cause some recession and this recession would be more marked at first. It is believed that it would gradually become less up to a certain point and then probably become fairly well fixed except for seasonal changes.

In endeavoring to reach any conclusion on such a subject careful consideration must be given to local conditions, in order that one should not be misled by the lowering of waters due to exceptional causes and which would not hold for the entire state.

It is my opinion that the lowering of waters is more or less local and that there is possibly some general lowering of the water level due to the general causes, such as excessive farm drainage, dredging, deforestation and cultivation. However, I doubt that the entire water level of the entire state is being lowered to any great extent or that there is any reason for anxiety due to such nominal lowering of levels as may have taken place.

It must be remembered that accurate records or investigations on this are not as a rule kept in water works and considering the information received and the wide variation in the answers, one is led to believe that a considerable amount of the lowering is more or less local.

A study of the questionnaire sent out to the different cities shows the following conditions:

Sixty per cent of those using well supplies state that there has been no lowering of the ground water.

Approximately 10 per cent cannot give any information.

About 30 per cent show a definite lowering of from 2 to 15 feet over a period of years, from as high as fifteen years.

Knowing personally the conditions of some of these wells in which the water has lowered, the writer arrives at the conclusion that some of this lowering is entirely local, but that, as a general thing, there

TABLE 1

Data on depths of wells in Indiana in 1927

COMMUNITY	DROP IN LEVEL	TIME	CAUSE
	feet	*years*	
Gas City	8		
Converse	0.3	8	
Noblesville	2–3½		
Elkhart	5	15	
Martinsville	4		
Connersville	3		
Muncie	5	15	
Kendalville	10	30	Drainage of lake
Yorktown	7	22	
Van Buren	5		
LaPorte	8	15	
Rensellaer	10		
Goodlawn	10	13	
Greentown	4	7	
Peru	5		Drainage of ditch
Fairmount	6	10	
Knightstown	Formerly flowing, now at various depth		
Lebanon	2	12	
Rushville	15		In some wells
Summittsville	6	20	

TABLE 2

Data on wells in 1910

TOWN	DROP
Kentland	48 feet in 5 years
Elwood	40 feet in 10 years
Greensburg	40 feet in 10 years
Muncie	28 feet (time not given)
Remington	8 feet in 10 years
Marion*	6 feet in 20 years
Butler	4 feet in 10 years
Bourbon	3 feet in 8.5 years
Linton	Some wells show 30 feet drop in 6 years
Kokomo	Some wells have dropped 15 feet since 1895

* The cause of the fall in Marion is given as due to waste from other wells.

is probably a slight lowering in the ground water level throughout the state. We also believe that, due to the excessive pull on many wells, especially in restricted areas, it is not correct to assume that this condition would be found over the entire state. There has been a lowering of the water level, due largely to farm tiling, drainage ditches and dredging, which has resulted in nearby areas being affected, but this effect becomes less as the distance from these improved areas increases.

As a matter of interest, we present in tables 1 and 2 data on the amount of lowering of certain water works wells in the state of Indiana.

SEDIMENTATION STUDIES OF TURBID AMERICAN RIVER WATERS[1]

By A. W. Bull[2] and G. M. Darby[3]

Since 1923 The Dorr Company has been making sedimentation studies of the waters of some of the turbid rivers of the middle west. This paper presents the summarized results of these studies with a comparison of the settling behaviour of the different river waters. The work has been carried out along several different lines, as follows:

1. Comparative clarification tests in 1-liter cylinders.
2. Comparison of clarification tests in cylinders with clarification in a continuous clarifier.
3. Clarification tests in deep cylinders.
4. Studies of sludge deposition, sludge thickening and sludge discharge.
5. Studies of the advantages of sedimentation prior to flocculation.

I. COMPARATIVE CLARIFICATION RATES IN SHORT CYLINDERS

The comparative clarification rates of the different waters have been determined by comparing the amounts of solids left in suspension after varying periods of sedimentation. These tests were made by placing 1 liter samples of the waters in one liter cylinders, 2.5 inches in diameter, allowing the cylinders to stand for varying periods, and then siphoning off the upper 12 inches of liquid, being careful to avoid drawing any sludge into the siphon tube. Portions of the unclarified water and of the clarified siphoned water were analyzed for suspended solids, using the standard Gooch crucible method, and the per cent of suspended solids removed by sedimentation were calculated. In many cases tests were made using both the water directly from the river and from the grit chambers of the treatment plant so that the effect of grit removal on subsequent sedimentation could be determined. The data obtained in these clarification tests

[1] Presented before the Chicago Convention, June 10, 1927.

[2] Research Engineer, The Dorr Co., Inc., New York, N. Y.

[3] Chief Chemist, The Dorr Co., Inc., Westport, Conn.

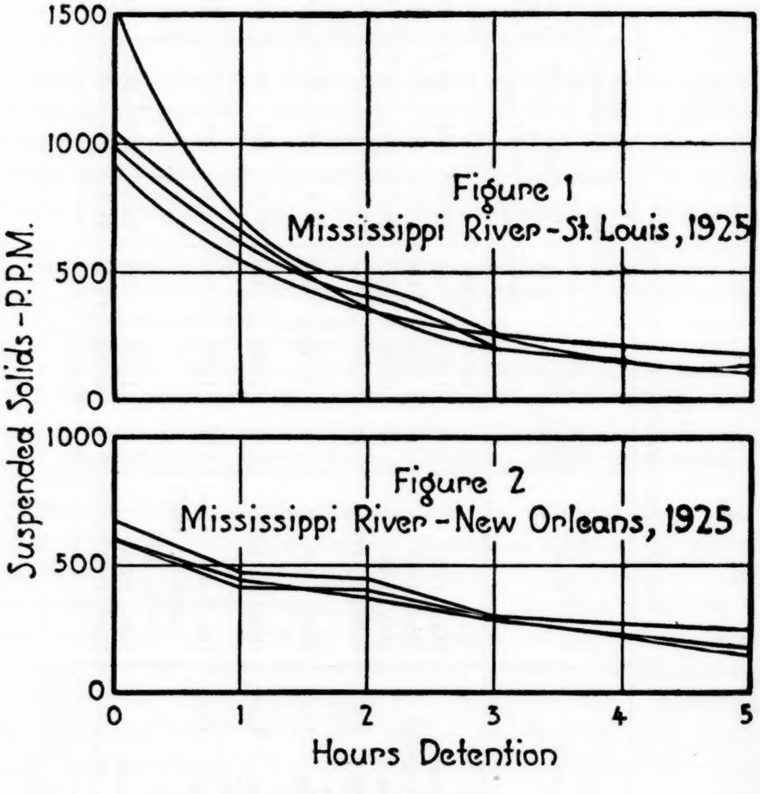
TABLE 1

Clarification tests on untreated river water

RIVER	PLACE	DATE	NUMBER OF TESTS	UNTREATED WATER	1 HOUR DETENTION		2 HOURS DETENTION		3 HOURS DETENTION		5 HOURS DETENTION	
					Clarified water	Per cent removal	Clarified water	Per cent removal	Clarified water	Per cent removal	Clarified water	Per cent removal
				p.p.m.	*p.p.m.*		*p.p.m.*		*p.p.m.*		*p.p.m.*	
Mississippi	St. Louis	May, 1925	4	1,126	563	48.6	364	66.4	239	77.8	138	85.8
Mississippi	New Orleans	May, 1925	3	629	448	28.9	417	33.9	310	54.2	189	70.6
Missouri	Omaha	May, 1925	7	2,065	447	69.2	195	84.9	120	91.1	65	94.6
Missouri	Kansas City, Mo.	October, 1923	18	7,435	612	91.8	318	95.8	221	97.0	168	97.7
Missouri	Kansas City, Mo.	May, 1925	6	3,138	595	80.4	245	92.0	149	95.2	91	97.1
Missouri	Kansas City, Kans.	October, 1923	1	2,439	425	82.6	187	92.5	126	94.9	89	96.5
Missouri	Jefferson City, Mo.	October, November, 1925; July, 1926	60	1,635	791	51.6	476	71.0	412	75.0	275	83.3
Missouri	St. Louis	May, 1925	3	1,755	571	64.5	288	83.5	170	90.2	77	95.2
Arkansas	Little Rock	May, 1925	6	2,934	1,040	61.1	521	80.2	333	87.3	242	90.7

on untreated water are summarized in table 1 while the individual tests are shown and summarized in figures 1 to 8.

There is a marked similarity in the behaviour of the different waters tested, except perhaps in the case of New Orleans where the suspended solids in the untreated water were comparatively low. At the end of three hours the turbidities are quite uniform for all the



FIGS. 1 AND 2

tests. Additional detention beyond this point produces a clearer water, but the improvement is hardly sufficient in most cases to justify the additional clarification equipment needed.

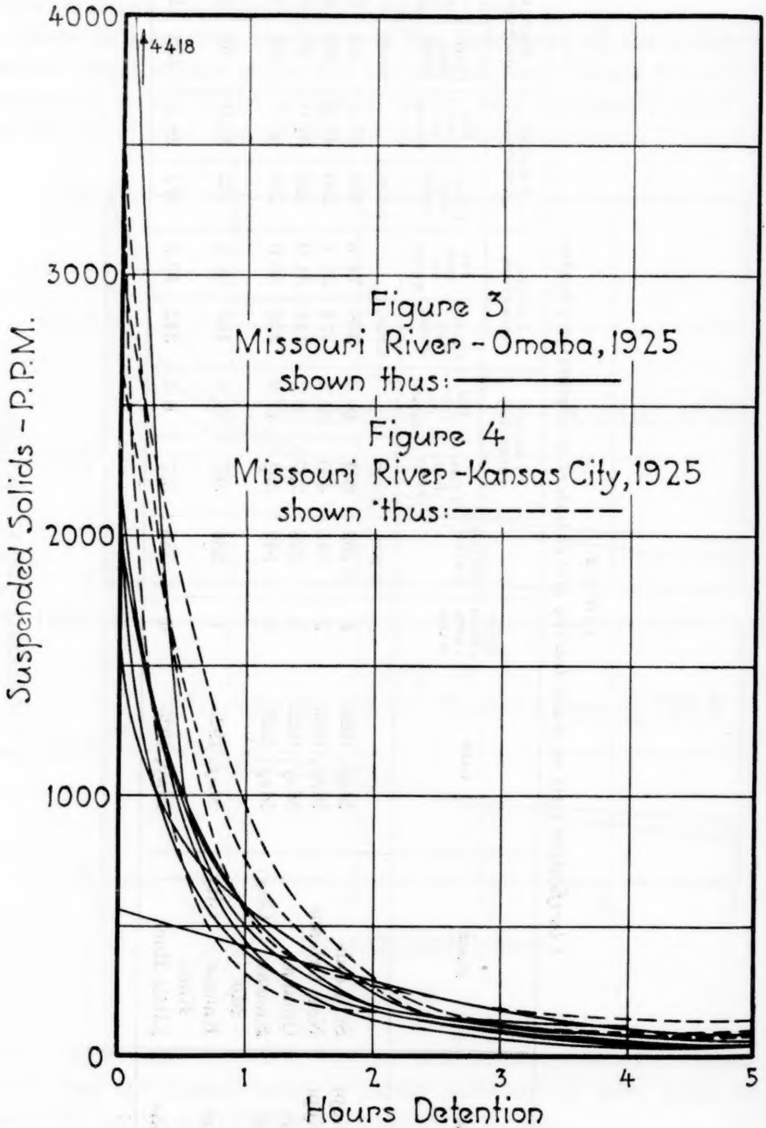
The data obtained in the clarification tests on water leaving the grit chambers or preliminary basins are shown in table 2.

In the clarification of turbid waters it has frequently been ob-

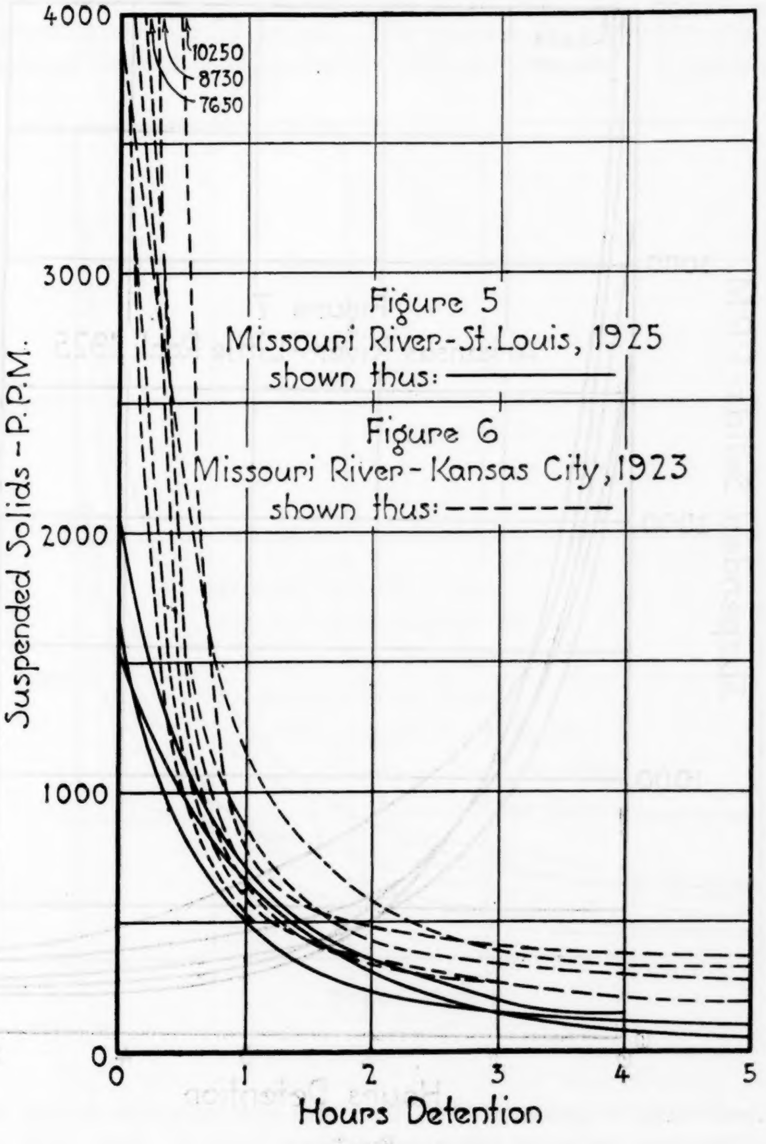
TABLE 2

Clarification tests on water leaving grit chambers or preliminary basins

RIVER	PLACE	DATE	NUMBER OF TESTS MADE	INITIAL WATER	1 HOUR DETENTION		2 HOURS DETENTION		3 HOURS DETENTION		5 HOURS DETENTION	
					Clarified water	Per cent removal	Clarified water	Per cent removal	Clarified water	Per cent removal	Clarified water	Per cent removal
				p.p.m.	*p.p.m.*		*p.p.m.*		*p.p.m.*		*p.p.m.*	
Mississippi	St. Louis	May, 1925	3	1,239	634	48.8	338	72.6	204	83.5	124	90.1
Mississippi	New Orleans	May, 1925	3	545	426	22.5	374	31.1	290	47.3	232	57.6
Missouri	Omaha	May, 1925	2	228	207	8.2	144	31.0	123	39.0	91	52.1
Missouri	Kansas City, Mo.	May, 1925	3	840	384	40.6	226	58.0	186	65.1	104	82.8
Missouri	Kansas City, Kans.	May, 1925	1	886	367	58.5	166	81.3	132	85.0	56	93.6
Arkansas	Little Rock	May, 1925	4	385	357	6.0	342	10.9	272	28.7	232	38.3


4000
3000
2000
1000
0
4418
Suspended Solids - P.P.M.
Figure 3
Missouri River - Omaha, 1925
shown thus: ————
Figure 4
Missouri River - Kansas City, 1925
shown thus: --------
0
1
2
3
4
5
Hours Detention

FIGS. 3 AND 4



4000
3000
2000
1000
0
10250
8730
7650
Figure 5
Missouri River-St. Louis, 1925
shown thus: ————
Figure 6
Missouri River-Kansas City, 1923
shown thus: --------
Suspended Solids - P.P.M.
0
1
2
3
4
5
Hours Detention

FIGS. 5 AND 6

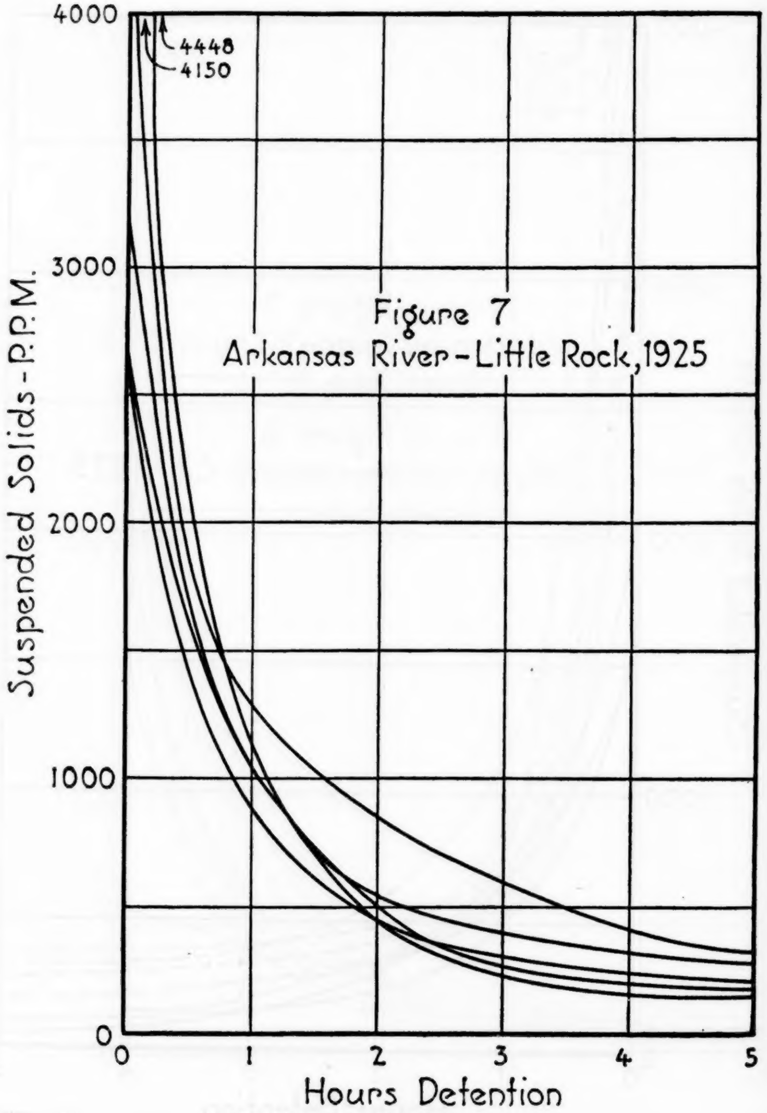

4000
3000
2000
1000
0
4448
4150
Figure 7
Arkansas River - Little Rock, 1925
Suspended Solids - P.P.M.
0
1
2
3
4
5
Hours Detention

FIG. 7

served that better results are obtained when the water contains a considerable amount of suspended matter than when the initial concentration of solids is low. This suggests the possibility of increasing the concentration of solids before sedimentation. A number

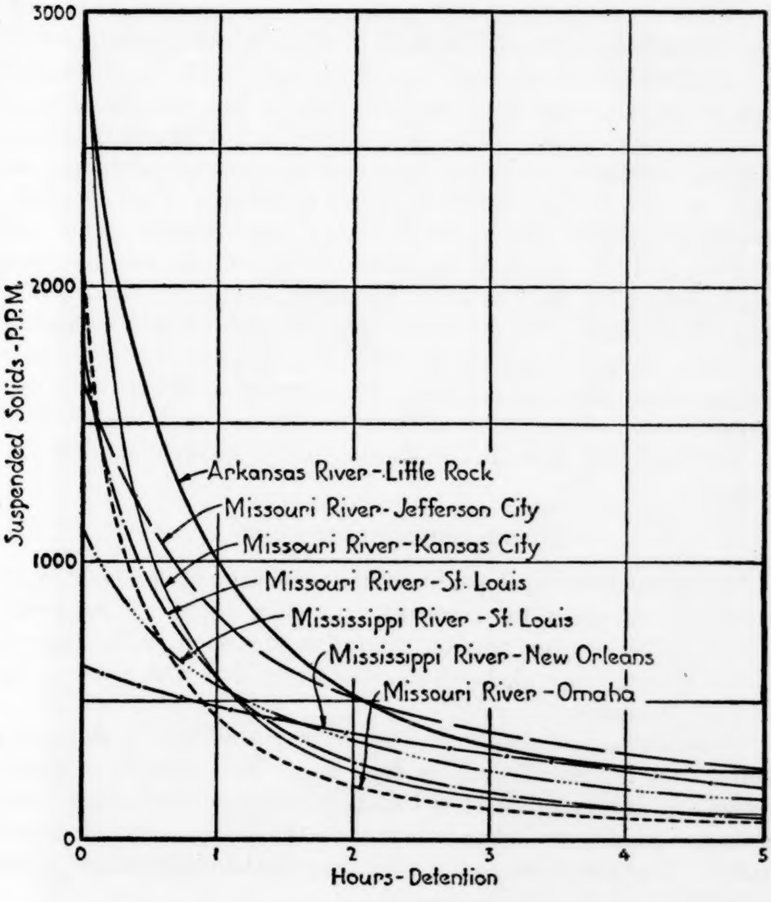


FIG. 8

of tests of this point were made at New Orleans and at Little Rock in May, 1925. In some cases, the untreated water was used and in other cases, the sample was taken after the water had passed through the grit chambers. Varying amounts of sludge from the plant coag-

ulation basins were added, as shown, to bring the concentration of suspended solids to the values given below. Clarification tests were then made in one liter cylinders as before. The data are given in table 3.

In general, the tests indicate an improved clarification in proportion to the amount of sludge returned. In some cases it will be noted that the addition of a small amount of sludge was detrimental while the addition of more sludge was beneficial. With an increasing concentration of solids the tendency for the settling particles to carry down the finer material is increased. There is good reason to believe that the returning of proper amounts of sludge would effect an improvement in the clarity of water overflowed from pre-sedimentation basins. This method should be of especial value and importance with waters of low turbidity which lack sufficient suspended solids for the formation of enough flocs to remove the fine, suspended solids. The Arkansas River is quite typical of such a condition (excess of fine solids). There are also periods of the year during which the concentration of suspended solids in the other rivers is too low for most efficient clarification and the returned sludge should be beneficial in assisting in the removal of these fine solids.

Turbidimetric measurements

During the work on clarification, the turbidities of various samples were determined by the standard method in use at the respective plants. The purpose was to determine the relationship between turbidity and suspended solids, and to note how this affected the ease of clarification.

Turbidity is not simply a measure of the weight of suspended solids, but is also affected by their size. For example, a certain weight of suspended solids when very finely divided has a much greater turbidity or hiding power than the same weight of coarser solids. The suspended solids divided by the turbidity gives a result called the "coefficient of fineness".

When this coefficient is about 1, the raw water clarifies quite rapidly and is fairly easy to treat. When the coefficient becomes 0.6 or less (turbidity is 1.6 to 2 times the suspended solids), it is usually found that the water will be rather difficult to treat.

The data obtained are given in table 4.

The average fineness coefficients for the raw waters in table 4 are

TABLE 3

Effect of adding sludge before clarification

PLACE	SOURCE OF SAMPLE	PARTS PER MILLION IN ORIGINAL SAMPLE	SLUDGE ADDED	RESULTING PARTS PER MILLION	DETENTION	PARTS PER MILLION AFTER CLARIFICATION	PER CENT REMOVAL OF SOLIDS*
			cc.		*hours*		
New Orleans	River water	614	0	614	3	296	51.8
New Orleans	River water	614	2	1,295	3	242	54.7
New Orleans	River water	614	5	2,316	3	190	64.4
New Orleans	River water	614	10	4,018	3	132	75.4
New Orleans	River water	610	0	610	3	295	51.7
New Orleans	River water	610	2	1,291	3	250	59.0
New Orleans	River water	610	5	2,312	3	189	69.1
New Orleans	After grit chambers	535	0	535	3	245	54.1
New Orleans	After grit chambers	535	2	1,216	3	500	6.5
New Orleans	After grit chambers	535	5	2,236	3	250	53.2
New Orleans	After grit chambers	535	10	3,940	3	215	61.6
New Orleans	After grit chambers	475	0	475	3	245	48.5
New Orleans	After grit chambers	475	2	1,156	3	270	43.2
New Orleans	After grit chambers	475	5	2,176	3	189	60.2
Arkansas	River water	3,180	0	3,180	1	1,020	67.0
Arkansas	River water	3,180	50	17,352	1	280	95.5
Arkansas	River water	3,180	0	3,180	3	290	91.0
Arkansas	River water	3,180	50	17,352	3	130	97.8
Arkansas	River water	4,150	0	4,150	2	860	79.3
Arkansas	River water	4,150	10	7,518	2	280	93.2
Arkansas	After grit chambers	400	0	400	2	340	15.0
Arkansas	After grit chambers	400	10	3,806	2	330	17.5
Arkansas	After grit chambers	400	0	400	3	160	60.0
Arkansas	After grit chambers	400	10	3,806	3	140	65.0

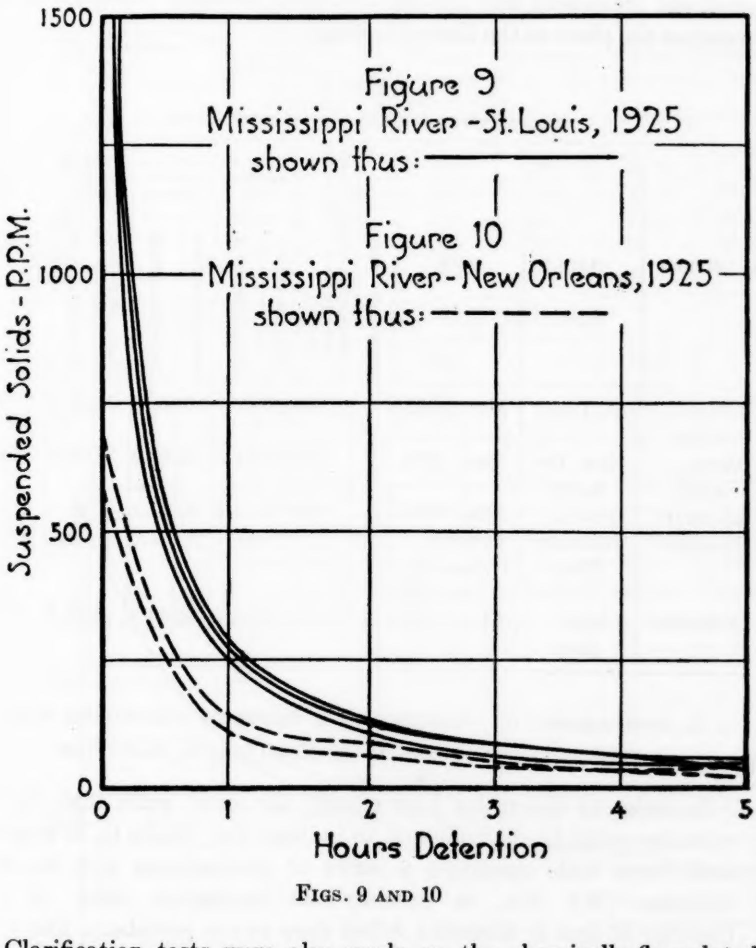
* Calculated on basis of solids in water before adding extra sludge.

TABLE 4

Tabulation of suspended solids and corresponding turbidities

PLACE	SAMPLE	FEED		1 HOUR DETENTION		2 HOURS DETENTION		3 HOURS DETENTION		5 HOURS DETENTION	
		Suspended solids	Turbidities	Suspended solids	Turbidities	Suspended solids	Turbidities	Suspended solids	Turbidities	Suspended solids	Turbidities
Omaha	Raw water									88	150
Omaha	Raw water									100	135
Little Rock	Raw water	3,130	4,500	1,440	3,000	670	1,400	400	1,000	280	600
Little Rock	Raw water	1,470	2,750	940	1,800	510	1,100	410	800	530	680
Little Rock	Grit spill	410	1,300	400	1,200	390	1,000	370	800	270	640
New Orleans	Raw water			475	1,080	455	1,056	338	891	255	819
New Orleans	Grit spill			555	1,209	435	1,056	380	1,005	278	729
New Orleans	Raw water			420	1,029	405	756	296	418	147	350
New Orleans	Grit spill			347	819	317	690	245	663	225	534
New Orleans	Raw water	610	900	449	837	390	728	295	670		
New Orleans	Grit spill			375	732	370	682	245	654		
Kansas City	Raw water	19,250	12,000	470	650	460	500	345	380	270	280
Kansas City	Raw water	8,730	10,000	610	650	190	300	150	260	90	170
Kansas City	Raw water	7,610	13,500	450	550	220	240	190	230	100	160
Kansas City	Raw water	4,340	5,800	690	600	310	320	235	230	195	160
Kansas City	Raw water	4,280	4,800	480	330	250	200	135	140	120	130

as follows: Little Rock, 0.62; New Orleans, 0.68; Kansas City (omitting the first result which is abnormal), 0.77. In comparison with these results the United States Geological Survey in Water Survey Paper No. 236 (1906–1907) found the fineness coefficient at Kansas City to be 1.07 and at Little Rock, 0.99.



FIGS. 9 AND 10

Clarification tests were also made on the chemically flocculated water at several plants using the one liter cylinders as previously described. While it is, of course, difficult to secure comparable data, due to the varying amounts of coagulants added at the different

treatment plants, the data obtained are submitted to indicate the general type of clarification curve which has been found on treated water. Figures 9 and 10 show the results for the Mississippi water at St. Louis and New Orleans. The summarized data are given in table 5. Samples, in all cases, were taken directly ahead of the plant coagulated water basins so they should be representative of the chemical treatment and mixing treatment actually being given the water at the plant at the time of testing.

TABLE 5

Clarification tests on treated river waters

RIVER	PLACE	DATE	NUMBER OF TESTS	FLOCCULATED WATER, PARTS PER MILLION SUSPENDED SOLIDS	1 HOUR DETENTION		2 HOURS DETENTION		3 HOURS DETENTION		5 HOURS DETENTION	
					Parts per million	Per cent removal	Parts per million	Per cent removal	Parts per million	Per cent removal	Parts per million	Per cent removal
Mississippi	St. Louis	May, 1925	3	1,534	226	85.3	121	92.3	78	95.4	39	97.7
Mississippi	New Orleans	May, 1925	2	650	101	84.5	79	87.9	38	94.0	35	94.5
Missouri	Omaha	May, 1925	1	120	110	8.3	97	19.2	67	45.0	40	66.6
Missouri	Jefferson City	October, November, 1925	8	920	115	87.5	85	91.0	45	95.2	40	95.8
Arkansas	Little Rock	May, 1925	2	230	110	55.8	45	80.4	25	89.3	20	91.4

II. COMPARISON OF CLARIFICATION TESTS IN CYLINDERS WITH CLARIFICATION TESTS IN A CONTINUOUS CLARIFIER

In order to determine how closely the small scale tests in liter cylinders could be depended on to indicate the results to be expected from large scale operation a series of comparisons were made at Jefferson City, Mo., in October and November, 1925. A Dorr Clarifier 25 feet in diameter, 8 feet deep at the periphery, and 9 feet deep at the center was installed at the plant of the Capitol City Water Company and supplied with untreated Missouri river water at rates corresponding to detention periods of two, three, four, five,

and six hours. At the same time, clarification tests were made in one liter cylinders using the method previously described. The data are given in table 6 and in figure 11.

TABLE 6

Comparison of laboratory tests and clarifier operation on river water—Jefferson City, Missorui

RIVER WATER, AVERAGE	DETENTION HOURS	NUMBER OF TESTS		IN EFFLUENT		PER CENT REMOVAL	
		Clarifier	Cylinders	Clarifier	Cylinders	Clarifier	Cylinders
October–November, 1925							
p.p.m.				*p.p.m.*	*p.p.m.*		
1,864	2	15	30	578	476	69.0	74.5
1,393	3	11	25	453	412	67.5	70.5
1,550	4	4	15	370	297	76.0	80.9
1,861	5	6	12	293	275	84.1	85.2
1,466	6	4	10	193	177	87.0	87.9
Clarifier operation, Jefferson City, July, 1926							
2,791	3	3		385		86.2	
6,263	3	5		333		94.7	
7,610	3	4		542		92.9	

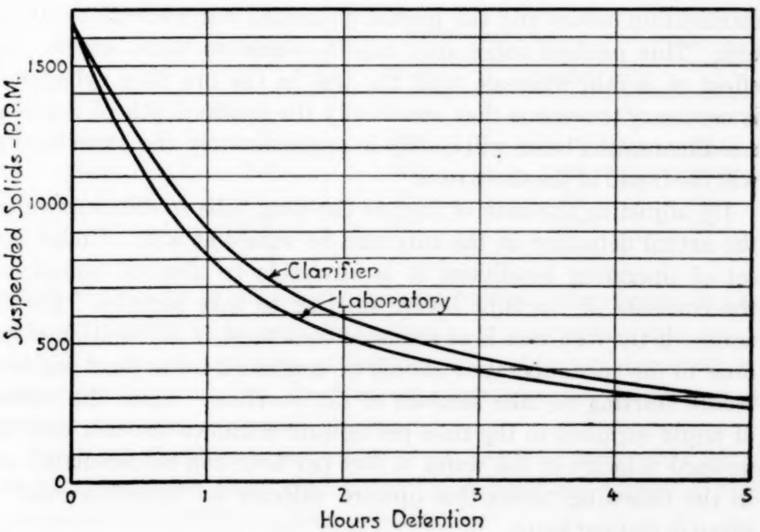


FIG. 11

The agreement between the small scale tests and the actual clarifier operation is quite good and sufficiently close to indicate that in cases of this kind the detention test in a one liter cylinder will give representative results. It is interesting to note that the concentration of solids in the overflow from the clarifier does not increase as the concentration of solids in the feed to the clarifier increases. An effluent of quite uniform turbidity is obtained and therefore the per cent removal of suspended solids increases with increasing feed concentrations.

It is also of interest to note that in small scale clarification tests on untreated river waters, the Jefferson City effluents were higher in suspended solids than were obtained at any other point. With the close agreement between the small scale tests and actual clarifier operation it is reasonable to assume that large scale operation on either the Mississippi or the Missouri will show even better results than those obtained from the experimental clarifier at Jefferson City.

III. CLARIFICATION TESTS IN DEEP CYLINDERS

Another method of approximating the settling conditions in continuous sedimentation basins is by means of a long vertical tube, supplied near the bottom with a continuous or semi-continuous flow of the water to be settled. As the water slowly rises in the tube clarification occurs and the partially clarified water overflows at the top. This method takes into consideration, to some extent, the effect of depth, whereas, with the test in the one liter cylinder, it is necessary to assume that practically the entire depth of liquid in a sedimentation basin will clarify in approximately the same time as will the liquid in the short tube.

By adjusting the rate of feed to the long tube to different values the actual detention in the tube can be varied at will. Under each set of operating conditions it is advisable to displace completely the contents of the tube before starting to take samples. For example, if the feed rate is so adjusted that there is a detention of one hour in the tube, operation should be continued for at least one hour before starting to take samples of the overflow. Since the volume of liquid supplied to the tube per minute is known in each case the upward velocity of the water in feet per hour can be calculated and in the following tables this upward velocity or "overflow rate" is given in feet per hour.

Tests of this kind were made on Missouri river water at St. Louis

in November, 1926. The water at that time contained only about 1000 p.p.m. suspended solids so the different concentrations used in these tests were prepared by allowing a quantity of the river water to settle in barrels so that some clarified water could be decanted. The results are shown in table 7.

These results do not agree with the clarification tests in one liter cylinders especially for the shorter detention periods where the

TABLE 7

Long tube tests on Missouri River water

DETENTION	OVERFLOW RATE	SUSPENDED SOLIDS		PER CENT REMOVAL
		Feed	Overflow	
hours	*feet per hour*	*p.p.m.*	*p.p.m.*	
1.0	13.0	9,141	4,088	55.4
2.0	6.5	9,141	2,575	71.8
2.5	5.2	9,141	1,230	86.5
3.0	4.3	10,464	297	97.2
2.0	6.5	1,228	261	78.7
3.0	4.3	1,803	80	95.6

TABLE 8

Long tube tests on coagulated Mississippi River water

DETENTION	OVERFLOW	SUSPENDED SOLIDS		PER CENT REMOVAL
		Feed	Overflow	
hours	*feet per hour*	*p.p.m.*	*p.p.m.*	
13.0	1.0	162	15	90.7
2.0	6.5	638	86	86.5
1.4	9.0	178	24	86.5
1.0	13.0	638	237	62.8

upward velocity in the long tube is fairly high. Agreement in those cases is hardly to be expected. Basins of excessive depth are undesirable, for in order to utilize the full volume of the tank it is necessary to introduce the feed at a considerable depth and this causes undesirable upward currents.

Long tube tests were also made at St. Louis on coagulated Mississippi river water from the mixing conduits at the Chain of Rocks plant and the results are given in table 8.

IV. STUDIES OF SLUDGE THICKENING AND SLUDGE DISCHARGE

In the operation of sedimentation basins it is necessary to provide either extra depth for sludge storage as solids accumulate in the basin or to arrange for continuous sludge removal. The question of the amount of water wasted in sludge removal is of considerable importance. It is possible to show that with proper methods of continuous sludge discharge, less water will be lost than by the intermittent sluicing of basins. It is also possible to show that the slow, continuous movement of rakes in the bottom of a clarifier is of distinct benefit in aiding the thickening of the sludge to its maximum density.

When fine solids, suspended in water, are allowed to settle undisturbed, the mud which collects at the bottom contains a large amount of water. The solids are loosely packed in a sponge-like network in which a considerable amount of water is trapped. If slow, but continuous, raking is provided, this network is destroyed and the water is able to escape with a consequent increase in the density of the sludge.

To demonstrate this phenomenon, the following experiment was made:

Two 1-liter cylinders were filled with a dilute suspension (approximately 3 per cent solids) of mud from the clarifier when it was operating as a pre-sedimentation unit on raw water and two more cylinders were filled with a similar suspension of mud which had been coagulated with iron sulphate and lime. The four cylinders were placed side by side, and a continuously rotating rod carrying small projecting arms was placed in one cylinder of each pair. This rod was operated at a speed comparable to that of the rakes in Dorr Clarifiers. The other two cylinders were allowed to stand undisturbed. The position of the sludge line was read at frequent intervals and from this and from the dry weight of the solids in the cylinders the per cent solids in the sludges at the various intervals were calculated. The data are given in table 9 and in figure 12.

It is evident that the rakes have a very pronounced action in hastening the thickening of the mud. The samples which were given slow but continuous raking reached a density in ten hours which was not equalled by the unstirred samples until forty-five to seventy-five hours had elapsed. At the end of seventy-five hours the raked samples contained much less moisture than the samples without raking.

In the tests with the experimental clarifier at Jefferson City the thickened sludge was discharged through an orifice. The concentration of solids in the sludge varied daily with changes in the nature of the solids in the raw water. The per cent water in the discharged

TABLE 9

Thickening tests on sludge from raw and dosed water

TIME	PER CENT SOLIDS IN THE SLUDGE			
	Sludge from raw water		Sludge from dosed raw water	
	Without rakes	With rakes	Without rakes	With rakes
hours				
0.0	2.80	2.94	3.26	3.26
5.0	6.4	13.3	10.3	15.4
9.5	11.9	18.5	12.3	19.6
20.5	15.0	21.7	14.1	23.8
30.8	16.3	23.5	15.4	25.3
46.3	18.2	25.2	17.2	27.4
59.5	20.0	25.8	18.5	27.4
77.5	21.1	26.3	19.6	27.6

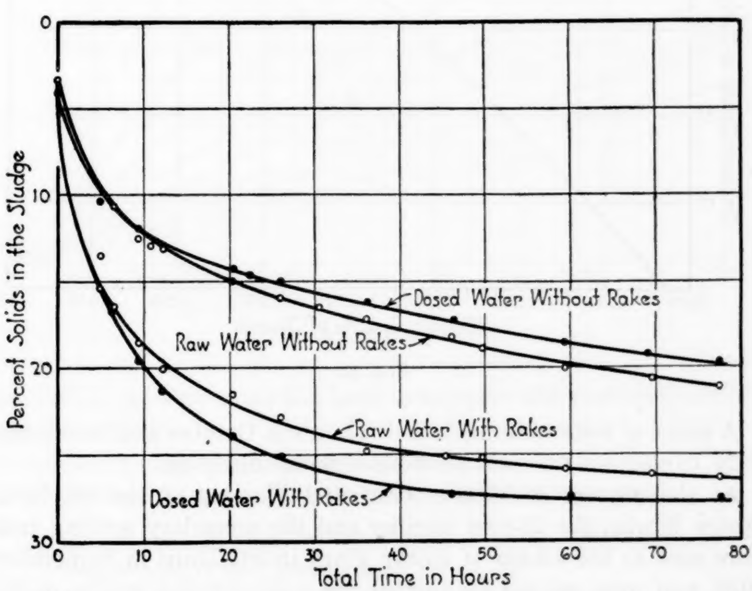


FIG. 12

sludge varied between 28 and 90 with a general average of 65 to 75. In a clarifier removing 2000 p.p.m. of suspended solids the volume of sludge discharged will amount to approximately 0.50 per cent of the volume of water sent to the clarifier. Figures 13 and 14 give curves from which the per cent solids in the sludge and the per cent of water lost in the sludge can be readily determined. Wet screen tests were made on a number of samples of sludge at Jefferson City with the results shown in table 10.

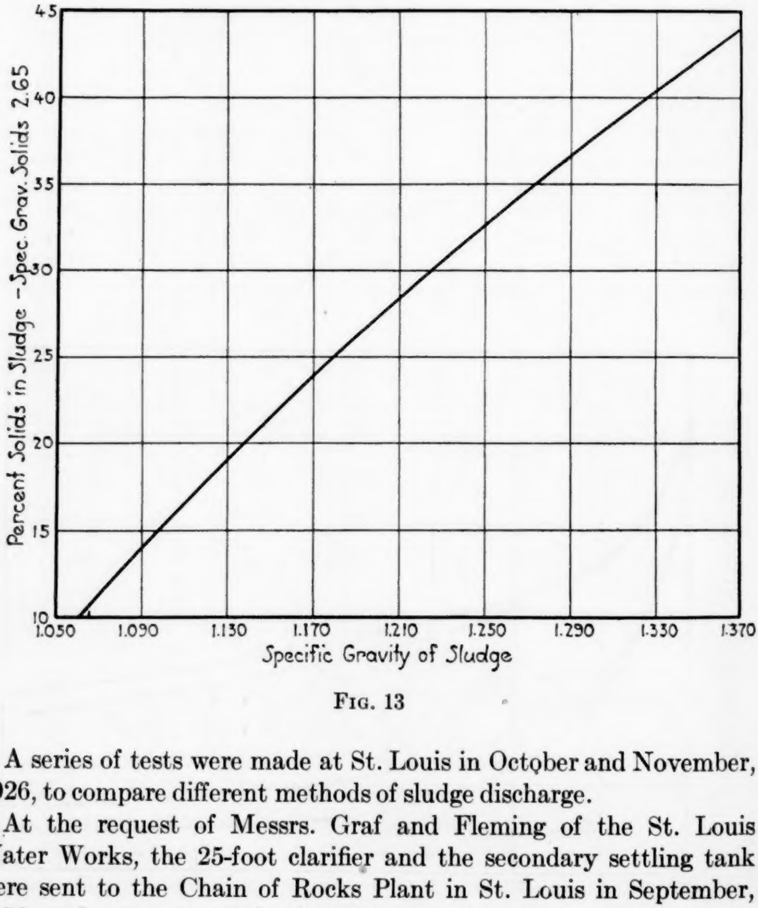


FIG. 13

A series of tests were made at St. Louis in October and November, 1926, to compare different methods of sludge discharge.

At the request of Messrs. Graf and Fleming of the St. Louis Water Works, the 25-foot clarifier and the secondary settling tank were sent to the Chain of Rocks Plant in St. Louis in September, 1926, and were erected for further pre-sedimentation studies on the Mississippi River Water. The tests at St. Louis in October and

November, 1926, were conducted by the staff of the St. Louis Water Works and with the coöperation of The Dorr Company.

The concentration of suspended solids in the river water was very low at this time so in order to obtain sufficient sludge to work with a combined sludge was prepared from approximately 22,000 pounds of river bank sand, 3000 pounds of grit chamber sand, and sludge from the No. 1 settling basin at the Chain of Rocks plant. This artificial sludge after discharge was thoroughly mixed with more water, then

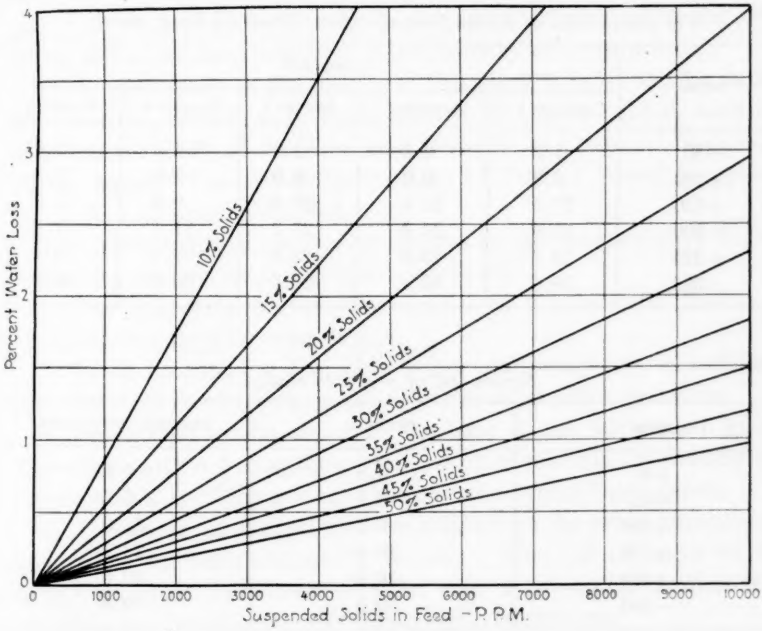


FIG. 14

recirculated and used in all the tests to compare different methods of sludge discharge.

A screen test of this sludge is given in table 11.

Three methods of controlling the sludge discharge were tried.

1. Discharge through a swivelled pipe which could be readily swung up or down to control the discharge head.
2. Combinations of the swivel pipe and different sized orifices.
3. By the use of a diaphragm pump.

The conclusions from these tests were as follows:

1. The clarifier demonstrated its ability to thicken river mud and to discharge the sludge with a water loss of less than 1 per cent.

2. For the handling of this type of sludge, the piping should be free from shoulders or any obstructions. Flange joints are recommended.

3. Either orifice or swivel discharge may be used, but both will require careful manipulation and fairly close attention.

TABLE 10

Wet screen tests of sludge from clarifier (Missouri River water)

MESH	PER CENT				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
+80	1.2	0.3	2.3	4.0	1.8
+100	2.2	0.9	6.9	2.0	2.3
+150	17.5	15.4	20.0	6.2	7.3
+200	27.8	24.0	27.7	11.1	11.1
+325	12.7	13.0	13.4	7.1	9.4
−325	38.5	46.4	29.7	69.6	68.1

TABLE 11

Screen test of prepared sludge

MESH	PER CENT	PER CENT CUMULATIVE
+48	0.8	0.8
+65	5.9	6.7
+100	6.2	12.9
+150	10.8	23.7
+200	16.8	40.5
−200	59.5	59.5

4. The diaphragm pump handled and controlled the sludge discharge without any difficulty and could consistantly remove sludge of a greater density than could be continuously discharged through an orifice or through the swivel pipe.

V. STUDIES OF THE ADVANTAGES OF SEDIMENTATION PRIOR TO FLOCCULATION

In conjunction with the operation of the experimental clarifier at Jefferson City it was decided to determine the effect of pre-sedi-

mentation on the amount of chemicals needed for satisfactory flocculation. A secondary settling tank 14 feet by 14 feet by 7 feet deep was installed together with two chemical mixing and storage tanks with the necessary piping, pumps and mixing launders.

The apparatus was so arranged that the river water could either be treated with chemicals and sent directly to the secondary settling tank or it could be given a preliminary sedimentation in the 25-foot diameter Dorr Clarifier and the effluent treated with chemicals and then sent to the secondary tank. In this way it was possible to compare directly the quantities of chemicals required for coagulating raw river water and for coagulating river water from which the bulk of the solids had been removed by preliminary sedimentation.

Only a summary of the results of this work is given in this paper, as complete details were presented at the Birmingham meeting, December 6, 1926, of the American Institute of Chemical Engineers, in the paper "The Pre-Sedimentation of Turbid Water Supplies" by A. W. Bull and G. M. Darby.

The advantages of pre-sedimentation in the treatment of highly turbid waters may be summarized as follows:

1. The reduction of turbidity results in a substantial saving in chemicals required for coagulation.

2. Pre-sedimentation furnishes water uniformly low in turbidity for secondary coagulation, resulting in smoother plant operation.

3. Pre-sedimentation removes the bulk of the suspended solids, thereby greatly reducing the accumulation of solids in the coagulating basins with a resulting saving in the cost of cleaning these basins.

4. The water discharged with the solids from the pre-sedimentation basins has not been chemically treated. The cost of water wasted in the sludge is therefore less in the case of pre-sedimentation than when the raw water is directly treated with coagulants.

5. Where the water is to be subsequently softened, preliminary tests indicate that pre-sedimentation will effect a considerable saving in lime.

In conclusion, the writers wish to express their appreciation for the hearty coöperation extended to them by those in charge of the water treatment plants where these tests were made.

TURBIDITY AND COAGULANT DOSAGE[1]

By Kenneth C. Armstrong[2]

Some difficulty has been experienced at the Omaha plant in determining the correct dosage of coagulants to use. There was considerable fluctuation in the quality of the water being treated and to insure a properly settled water reaching the filter plant an excess of alum was often used. Factors which influence the coagulant dosage such as variable rates of pumpage and fluctuation in the turbidity of the settled water before treatment were not responsible for many changes which were noticed in the quality of the treated water. The results were that at various times dosages of alum were added which were in excess of the actual requirements, because the chemist did not know whether a rise in turbidity of treated water was only a temporary condition due to known causes or to some change in the quality of the water entering the plant.

In starting the investigation the problem was attacked from both the chemical and the physical side. It was considered likely that the sulfate content might be an influencing factor. Numerous quantitative analyses were made for sulfates. It was found that sediment settled very readily whether the sulfate content was high or low. Oxygen consumed determinations were made in an effort to disclose the presence of organic, probably colloidal materials which were causing the undesirable conditions at times. After a number of determinations were made it was apparent that no information could be obtained from this source. Hydrogen ion concentration was found to be very near the optimum value for this water.

River turbidity did not have any influence upon coagulant requirements. At times when it was as high as 12,000 p.p.m. the water was often more easily settled than when the turbidity was a fraction of this amount.

After the water left the grit chambers and was ready for chemical

[1] Presented before the Iowa Section meeting, September 28, 1927.

[2] Chemist in Charge of Filtration, Florence Filter Plant, Metropolitan Utilities District, Omaha, Nebraska.

treatment it showed considerable fluctuation in turbidity from day to day and even from hour to hour. The turbidity of the settled water did have some effect upon coagulant requirements, that is, a water having a turbidity of 400 p.p.m. could be treated with 0.25 grain per gallon less of alum than water with a turbidity of 600 p.p.m. But it was also found that water having 400 p.p.m. turbidity did not require the same dosage of coagulants at all times even though the rate of pumpage was the same. Settled water turbidity influenced somewhat the amount of coagulants required, but it did not indicate the quality of the water. Its value is of some use in determining the amount of coagulants required. Settled water turbidity is determined every two hours when muddy water is entering the plant.

Settling tests were made on river water to find if some method of measuring the finely divided material which tended to remain in suspension could be worked out. At first a liter graduate was used. River water was premitted to stand in the graduate for various lengths of time after which samples were siphoned off at the top for turbidity tests. It was apparent that the heavier mud which was slow in settling was having an influence by causing them to show a higher value at times by inhibiting the settling of the fine material. A $5\frac{1}{2}$-foot glass cylinder was tried and this gave much more satisfactory results. Samples were allowed to stand for 1, 2, 3, 6 and 24 hours. The turbidity in 1 hour showed a fairly constant value. That is, there usually was no change, whether the chemicals required were high or low. It was apparent that this determination was not of any value. The 2-hour turbidity tests were more successful. Greater fluctuations were noticed from day to day, but it had a tendency to show a high value when the original river turbidity was high due to the effect of heavier sediment inhibiting the settling of the finely divided material which was to be measured by the test. The 3-hour turbidity test showed a range of values varying from 40 to 600 p.p.m. It was found that the coagulants required could be governed largely by the results obtained from this determination. The 6-hour turbidity test showed more constant values and did not change with every change in coagulant requirements. Turbidity tests made after 24 hours did not show much change, except when the water contained very finely divided material almost colloidal in nature. At such times this value has been as high as 140 p.p.m.

Three hour turbidity tests are made daily at the laboratory. They

usually show a fairly constant value for several days. When an increase is noticed in their value, a gradual rather than a quick change in the water being treated is noticed. This is due to the detention period between the river and the point where the chemicals are applied. At such times the alum is raised to meet the new conditions. When the value shows a decrease, a gradual improvement in the water takes place, and the alum dosage is decreased accord-

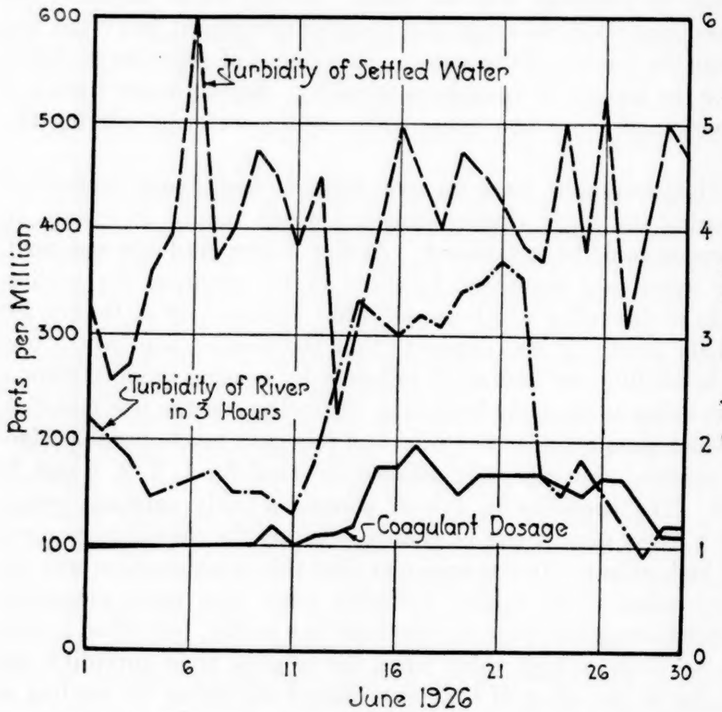


FIG. 1. ALUM DOSAGE, SETTLED WATER TURBIDITY AND TURBIDITY OF RIVER WATER AFTER SETTLING THREE HOURS

ingly. This is illustrated in figure 1 showing the settled water turbidity, 3-hour turbidity, and the alum dosage for the month of June, 1926. For the first 11 days of that month the water was in a condition which required only a moderate dosage of alum. The settled water turbidity fluctuated from day to day, but not enough to have much influence upon coagulant requirements. The 3-hour turbidity, however, showed a decided increase at the middle of the

month and this brought a corresponding increase in coagulant dosage. Such a change is typical of this supply, although most of them do not last for so long a time and do not result in such an increase in alum dosage. In this case there is more time between the drop in the 3-hour turbidity and the cut in alum dosage due to the high pumpage at that time. For most months of the year there is not so much fluctuation in chemical dosage. Often it is possible to run for a month without a change.

Since these tests have been made in the laboratory several unusual conditions have been found in the quality of the water being treated. After the flood in Sioux City in September 1926, a very dark colored mud came into the plant. The settling experiments proved it to

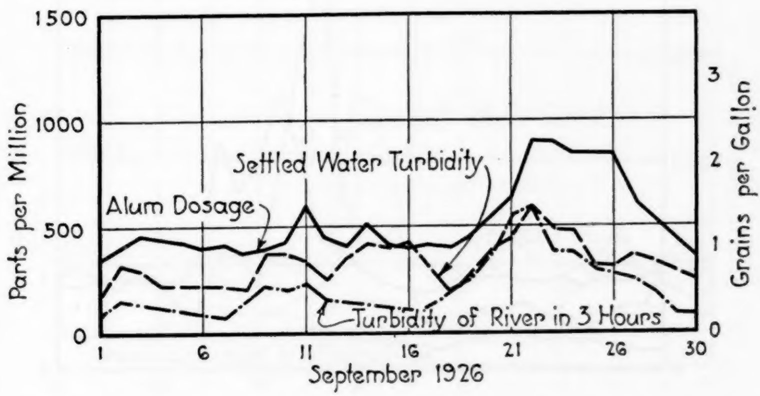


Fig. 2. Alum Dosage, Settled Water Turbidity and Turbidity of River Water after Settling Three Hours

contain the largest amount of finely divided material that has been found in the past two years. The curves in figure 2 showing the settled water turbidity, 3-hour turbidity, and alum dosage for the month of September give an idea of the influence of slow settling material on chemical dosage. During this month we did not have any highly turbid settled water and no extra dosage of chemicals was required. The turbidity in 3 hours, however, was as high as 600 p.p.m. and required a decided increase in chemicals. A much larger dosage would have been used if the settled water had shown a corresponding increase in turbidity.

In July, 1926 the pumpage was extremely high (see fig. 3). The result was that the turbidity of the settled water before it received the chemicals gradually increased until it reached 2000 p.p.m. The 3-hour turbidity tests, however, did not show a corresponding increase. This water was treated by applying the alum at two points. A dosage sufficient to get the water down to a few hundred parts per million was applied and then a second dosage was applied to the effluent of the next basin in the series. The second dosage was very effective and produced a clear treated water with a small amount of coagulants due to the small quantity of slow settling material in

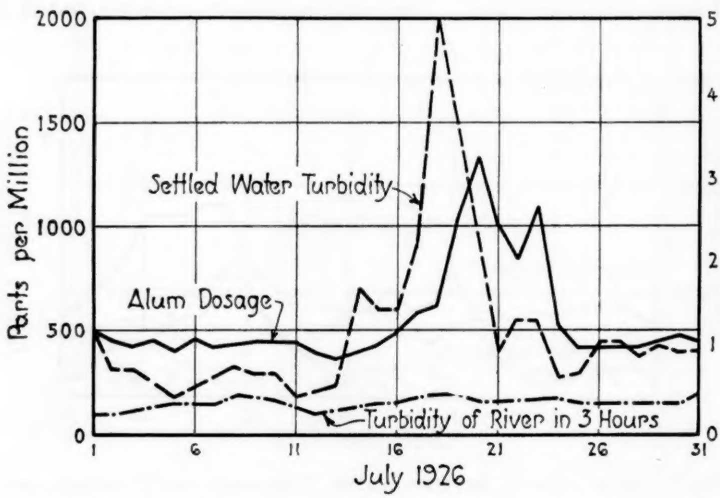


FIG. 3. ALUM DOSAGE, SETTLED WATER TURBIDITY AND TURBIDITY OF RIVER WATER AFTER SETTLING THREE HOURS

suspension. In this case more alum was used than was necessary because it was the first time that we had encountered a condition of this kind and we did not know what results to expect from the chemicals.

In May, 1927 (fig. 4) the river was higher than it had been for many years. The turbidity was around 10,000 p.p.m. The heavier material was slow in settling, however, and the result was that the first three basins were filled with suspended material and the water as it received the alum had a turbidity of 7500 p.p.m. The 3-hour turbidity at that time was 300 p.p.m., which indicated

that after the heavy mud was settled a second rather heavy dosage of alum was required. The first addition of alum was sufficient to bring the water to 600 p.p.m. after passing through one basin. A second dosage was then added which was sufficient to bring it to the filter plant in proper condition. The curves for the month of May 1927 show the conditions as they were at that time. That type of suspended material was the worst that has been encountered thus far. If it had lasted for a longer period the basin receiving the water after the addition of chemicals would have been filled with mud and the secondary dosage of alum would not have been effective, due to

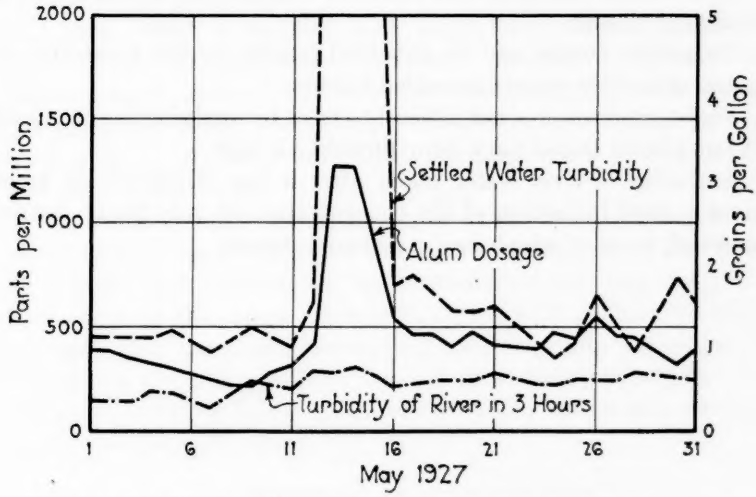


FIG. 4. ALUM DOSAGE, SETTLED WATER TURBIDITY AND TURBIDITY OF RIVER WATER AFTER SETTLING THREE HOURS

the high turbidity of the water at the second point of application. The situation could have been improved in such a case by applying the alum at three points instead of two.

It has been found that the 3-hour turbidity test did not indicate the same dosage at all times even though its value, the turbidity of the settled water, and the pumpage were constant. More alum is required when the results obtained from settling the river water for 24 hours are high. That is to say, a turbidity of 250 parts per million in 3 hours and 30 parts per million in 24 hours could be settled with a much lighter dosage than water with a turbidity in 3 hours

and 100 parts per million in 24 hours. This is especially noticeable in February when the river breaks up. At that time the water settles to 300 in 3 hours and as high as 140 p.p.m. in 24 hours. Such water is very difficult to treat so that part of the suspended material will not pass the filters. During the greater part of the year, however, not much fluctuation is noticeable in the 24-hour turbidity. Most change takes place in 3 hours and from that test the coagulant dosage is largely governed.

CONCLUSION

The material in suspension is chiefly responsible for fluctuation in coagulant dosage.

Coagulant dosage can be governed largely by the turbidity obtained after river water has settled 3 hours.

Very turbid water is not difficult to treat by applying the chemicals at two placed unless the 3-hour turbidity is high.

Turbidity of river water taken after it has settled for 24 hours gives a good indication of the concentration of very finely divided material, some of which is of a colloidal nature.

THE EFFECT OF SLIGHTLY ALKALINE TAP WATER UPON SPAWN AND EGGS OF TROUT AND PERCH

By Edward S. Hopkins[1]

During February, 1926 this laboratory was advised by the Conservation Commission of Maryland that it was impossible to hatch or raise brook and rainbow trout in their hatchery located in Druid Hill Park, which is supplied with water from the city mains. A plan of study was undertaken to learn, if possible, the cause of this high mortality among the fish. Two possibilities seem to govern this abnormal condition, namely excessive oxygen content in connection with very cold water and the elimination of free carbon dioxide from the supply.

The fish were kept in running water in the usual shallow trough about 12 feet long by 12 inches wide and 6 inches deep. The brook trout eggs were hatched on the customary trays and the yellow perch eggs in the usual Meehan fish jars with running water, so arranged that the spawn would find their way into an aquarium. The spawn was then placed in the trough as described above. The fish were fed at regular intervals and necessary care was given them by the hatchery attendant.

EFFECT OF COLD AND OXYGEN

It seems to be the opinion of gold fish fanciers that when fish are living in water under very cold conditions, 40°F. or less, with resultant high absorption of oxygen, excessive mortality may be experienced. This is particularly true if a large volume of cold water is flowing through a trough or aquarium. Therefore it seemed logical to study this condition first. Analysis of the results in table 1 will show that relative velocity of flow from a tap into an aquarium or trough has little bearing upon the amount of oxygen present in the water, since the low velocity (1 gallon per minute) and the high (6 gallons per minute) gave an oxygen absorption of approximately 80 per cent

[1] Principal Sanitary Chemist, Montebello Filters, Bureau of Water Supply, Baltimore, Maryland.

saturation. It is realized that there is a point of minimum flow where the oxygen would be given off to surrounding air, but this point is below the volume necessary to maintain fish life.

In the trough of which figures are presented in the column marked "D" in table 1, the trout grew normally, while in the first two troughs

TABLE 1

Comparison of oxygen content, velocity and temperature of water

Experiment conducted from March 1 to March 24

TROUGH "A"			TROUGH "B"			TROUGH "D"		
Velocity of flow (gals. per min.)	Temperature	Saturation of oxygen	Velocity of flow (gals. per min.)	Temperature	Saturation of oxygen	Velocity of flow (gals. per min.)	Temperature	Saturation of oxygen
	°F.	*per cent*		°F.	*per cent*		°F.	*per cent*
5.8	36	82.8	3.3	37	82.3		33	78.4
6.0	36	80.5	3.5	37	77.0	1.0	36	82.7
5.5	37	83.5	2.7	37	72.6	1.0	37	80.4
7.4	37	79.9	2.6	37	80.6	1.0	37	80.4
6.8	35	85.0	2.4	36	84.9	1.0	36	84.9
5.9	35	87.4	2.5	36	82.0	1.0	37	83.4
7.4	37	86.4		37	82.6	1.0	38	81.1

TABLE 2

Chemical analysis of the various water used in the experiment

Results expressed in parts per million

	SATURATION OF OXYGEN	CO_2	pH	ALKALINITY	TOTAL SOLIDS	LOSS ON IGNITION	Fe	Al	Ca	Mg	Cl	SO_4
	per cent											
Lewistown..........	85.61	3.2	6.5	8.0	30.4	19.2	0.1	0.4	0.6	1.0	2.5	Trace
Baltimore...........	82.00*	0.0	8.0	36.0	67.6	29.0	0.1	0.4	8.4	3.0	5.5	10.0
Spring.............	45.00*	28.0	6.3	54.0							7.0	

* Average figure.

they all died. This would indicate that factors other than a high oxygen absorption were responsible. A high oxygen content is to be found in natural streams during cold water and fish live normal though dormant lives. It is of interest to note that the oxygen con-

tent of the water supplying the Lewistown hatcher, from which the trout were taken, contained oxygen equally as high as that found in the city supply. (See table 2.) Studies by Powell (1) indicate that, in warm water with high oxygen content, the subsequent liberation of the gas causes strangulation, approximating the condition experienced by man in high altitudes.

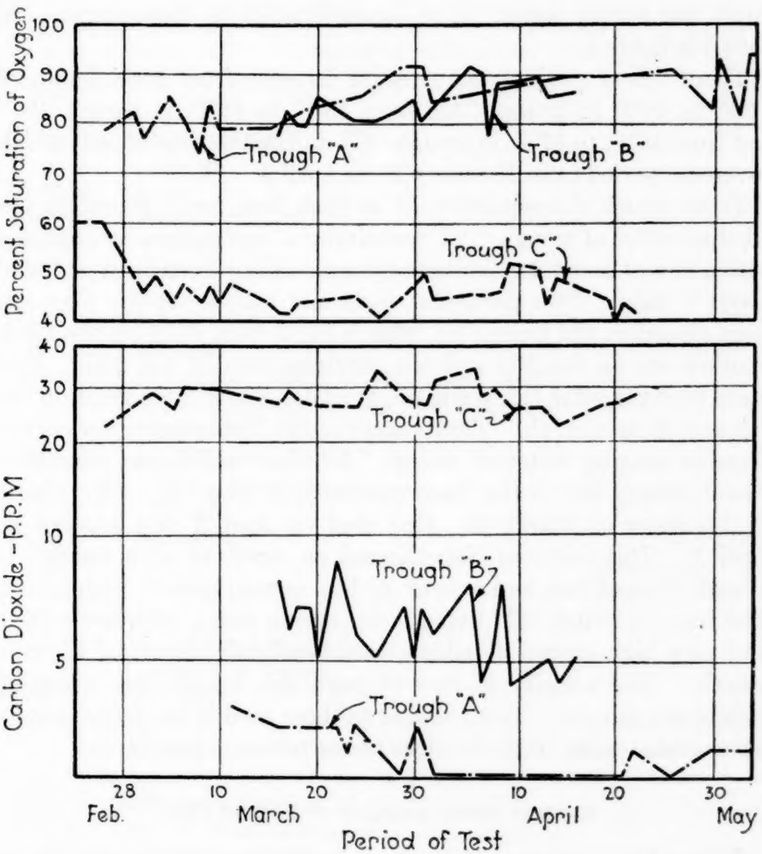


FIG. 1

EFFECT OF ALKALINE AND CARBON DI-OXIDE CONTAINING WATER

Comparing the analysis of the Lewistown and Baltimore City waters, table 2, it is at once noticed, as would be expected, that the

natural water contains free carbon di-oxide which is not true of the city supply, since a part of the purification process eliminates this condition. Fortunately, it was possible to pipe temporarily a supply of natural spring water into the hatchery and observe the effect of this environment upon the fish. Three types of water were available for the test. High oxygen and alkaline; high oxygen containing free carbon di-oxide and low oxygen free carbon di-oxide bearing. The latter was spring water. The characteristics of these waters are shown in figure 1.

There was a gradual temperature increase from a minimum of 37°F. to 48°F. in trough "A;" from 35°F. to 45°F. in trough "B;" and from 45°F. to 57°F. in trough "C" during the time of test, which covered a period from February 23 to April 9.

Trout about three-quarters of an inch long were placed in the alkaline water of trough "A," containing a high oxygen content and with a flow of about 2 gallons per minute. They lived for a period of about 7 days. Two particular instances will be cited. Five fish were placed in the trough on March 19; 2 were dead on the 23rd; another one on the 24th and the surviving two on the 26th. Five more were placed in this water on April 1. Three were dead on the 7th and all on the 8th. Trout placed in the high oxygen, low carbon di-oxide bearing water of trough "B" show a different condition. About twenty-five of the three quarter inch long trout were placed in this water on March 16. One died on April 7 and another on April 8. This test was discontinued on April 16 with the fish in a healthy condition and a more or less normal growth maintained. The trout in trough "C" living in the spring water, with low oxygen and very high carbon di-oxide content maintained normal life constantly. The velocity of flow through this trough was about 1½ gallons per minute. Trout similar to those used in the other troughs developed steadily until the close of the test on April 22.

EFFECT UPON YELLOW PERCH SPAWN

Yellow perch spawn and eggs were under observation from March 6 to April 20. The temperature range during this period was from 43°F. to 52°F. in trough "A" and from 48°F. to 52°F. in trough "C." Velocity and other conditions were similar to those governing the test for trout. (See figure 1 and table 3).

A quantity of spawn were placed in trough "A" on April 19 and all

died within 48 hours. A second batch lived for 4 days, from April 19 to 23 and a third survived only 48 hours, from May 1 to 3.

A quantity of eggs were placed in the excessive carbon di-oxide

TABLE 3

Log of fish life cycle

	TROUGH "A"	TROUGH "B"	TROUGH "C"
Feb. 26			150 trout placed in trough
Mar. 16		25 trout placed in trough	
Mar. 19	5 trout placed in trough		
Mar. 23	2 dead		
Mar. 24	1 dead		
Mar. 26	All dead		
Apr. 1	5 trout placed in trough	1 dead	
Apr. 7	3 dead	1 dead	
Apr. 8	All dead		
Apr. 19	50 yellow perch spawn placed in trough	Test closed Apr. 17, fish healthy	
Apr. 20	All dead. New batch placed in trough		
Apr. 22	Some dead		Fish lived normally—test closed
Apr. 23	All dead		
May 1	25 additional spawn placed in trough		
May 3	All dead		

Yellow perch spawn in Meehan fish jar. Spring water used.

Apr. 7	250 spawn placed in jar
Apr. 19	50 additional placed in jar
Apr. 22	Tap water, slightly alkaline, (pH 8.0) substituted at 4 p.m. All fish dead in this water at 8 a.m. Apr. 23.

bearing spring water using a Meehan jar. Upon hatching the spawn was kept in a portion of trough "C" (spring water). This test was started on April 6 and continued until April 22, the jar being removed

upon the hatching of the majority of the eggs. The supply of spring water was discontinued at 4 P.M. on April 22 and tap water substituted. All of the fish were dead at 8 A.M. on April 23. A striking condition as reported in the beginning of the test was that the perch would hatch in the Meehan jars containing tap water, but would not thrive afterward. It is of interest to note, as shown in table 4, that the water in these jars contained free carbon di-oxide even though the water supplied did not. Samples collected from April 13 to 26 showed the presence of carbon di-oxide. This was absorbed from the air, since the water entering the jar as analyzed on the 26th did not contain free carbon di-oxide, while the effluent from it did.

TABLE 4

Analysis of slightly alkaline tap water upon entering and leaving a Meehan fish jar

DATE	ENTERING			LEAVING			
	CO_2	pH	Saturation of oxygen	CO_2	pH	Saturation of oxygen	Remarks
	p.p.m.		*per cent*	*p.p.m.*		*per cent*	
Apr. 13				0.8	7.2	84.6	
Apr. 14				1.3	7.1	90.8	
Apr. 19	2.0*	8.4	90.6	0.4			
Apr. 20	3.0*	8.5	91.0	0.0	8.4	91.0	
Apr. 21	2.0*	8.5	91.1	0.0	8.2	84.3	
Apr. 22	1.2	7.2	90.6	1.8	7.0	84.6	
Apr. 26	2.0*	7.8	91.8	1.8	7.0	90.0	
				2.2	7.0		Sample taken from additional jars
				1.8	7.1		
				2.0*	7.6		Sample from bottom of jar at inlet

*CO_3—water alkaline for fish life.

FUNGUS GROWTH

Fungus growth was noted during the period of cold water in conformity with Gwynn (1), but was not present upon the eggs or fish used in this study. This growth was noted upon full grown fish of various species in the hatchery. Hall (2) suggests that fungus growth is in direct proportion to the oxygen present and is usually derived from dead eggs or protoplasm. Knowing that with cold water there is a supersaturation of oxygen, this condition is in accord with the results quoted above.

ADDITION OF CARBON DI-OXIDE TO TAP WATER

It was of interest to learn whether artificial carbonation of the tap water could be successfully accomplished. Perch spawn placed in such water from May 1 to 12 maintained normal life as shown in table 5. This treatment produced a high oxygen, low carbon di-oxide water, with a temperature range from 51°F. to 57°F. Carbonation was easily handled by attaching a Hoke Phoenix gas regulator to a tank of carbon di-oxide, as supplied to the soda fountain trade, and adjusting the flow of gas by counting the number of bubbles per minute passing through a water bottle contained in the train. Since only slight acidity was desired it was concluded that a pH value of about

TABLE 5

Application of carbon dioxide to tap water

DATE	INITIAL pH*	BUBBLES (CO_2 PER MIN.)	FINAL pH	CO_2	SATURATION OF OXYGEN	REMARKS
				p.p.m.	*per cent*	
Apr. 30	7.3	32	6.7	8.8	87.5	
May 1	7.5	60	6.4	13.2	91.2	25 spawn placed in trough
May 3	7.5	48	6.7	7.0	83.0	
May 4	7.3	43	6.7	8.8	91.2	
May 5	7.2	50	6.7	5.3	90.0	
May 6	7.5	44	6.7	7.0	80.6	
May 12	7.2	42	6.7	7.0	82.0	Fish removed in healthy condition
May 13	7.3	37	6.8	4.4	80.0	
May 17	7.3	36	6.7	7.4	74.3	
May 20	7.3	38	6.3	17.6	76.0	

* Obtained from daily plant records.

6.7 would be proper. (See figure 2 and table 5.) Adjustment to this value was made possible by the use of brom thymol blue indicator and was successful without the use of standards. It was not difficult to adjust the flow of gas to the required volume for production of the desired green color, as excess of gas gave the characteristic yellow color and an insufficient flow a blue tint in the test sample. Thirty-five to 45 bubbles per minute of gas as passed through the bottle, maintained a pH value in the tap water of about 6.7, working against a water pressure of 45 pounds per square inch.

The human factor is to be considered with such an installation,

yet it is believed that the type of personnel operating a hatchery is of sufficient intelligence to properly manipulate the apparatus and will devote the necessary time to its supervision and control. A series of such installations may be of practical benefit in overcoming alkaline water where another source is not available.

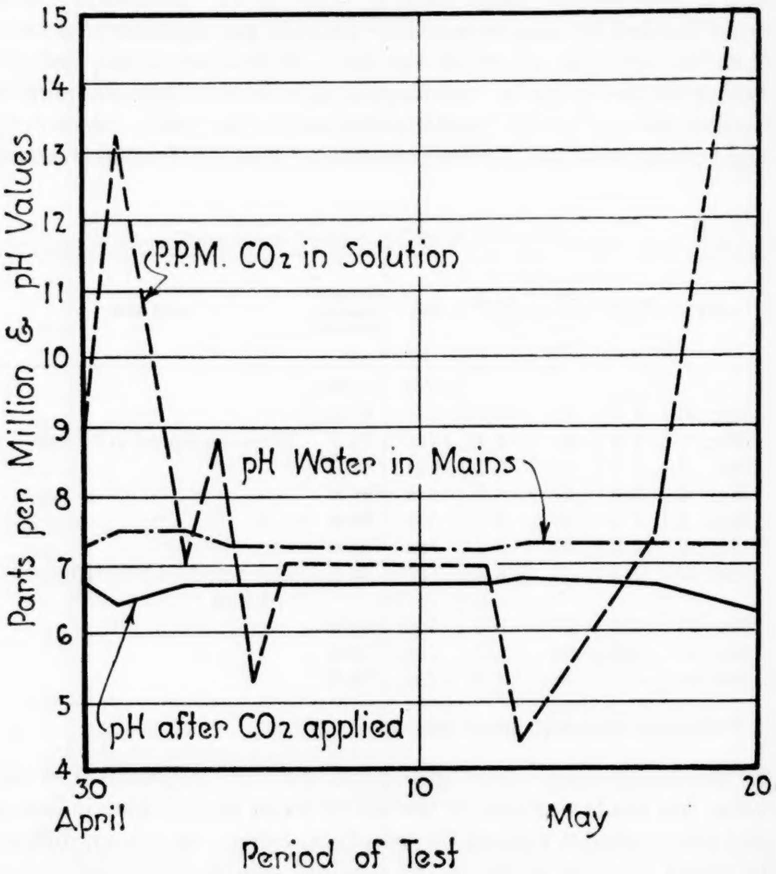


FIG. 2

CONCLUSIONS

Water delivered from a tap to troughs or an aquarium under very cold conditions is usually saturated with air. The amount of free oxygen present is little affected by a volume of flow greater than one

gallon per minute. Apart from the fact that cold water absorbs greater quantities of oxygen than warm water and that below 41°F. fish become very sluggish, a reasonable decrease in temperature does not produce high fatality. Britton (3) shows that carp (gold fish), if kept constantly in a flowing stream at 30°F. will die. Since the minimum temperature of water delivered in the city is 33°F., this factor does not enter into the test.

It is well known that brook trout enjoy restricted association in their relation to other fish life. Coker (4) suggests that a high oxygen content is necessary to maintain life in this species and they thrive better in water of marked acidity (pH 6.0) due to the presence of carbon di-oxide. The results obtained in this study show that even

TABLE 6

Showing the resistance of 4 to 6 month old trout to the toxic effect of slightly alkaline tap water

DATE	CO_2	pH	°F.	SATURATION OF OXYGEN	REMARKS
				per cent	
Apr. 6	10.0	8.9	43	93.0	Five trout placed in trough
Apr. 7	8.0	8.7	42	86.2	
Apr. 8	8.0	8.7	46	89.9	
Apr. 9	3.0	7.7	43	88.1	
Apr. 12	4.0	8.0	45	89.1	
Apr. 14	3.0	7.9	45	86.2	
Apr. 16	6.0	8.6	46	88.1	
Apr. 19	5.0	8.5	46	85.6	Test closed—fish living normally.

in very cold water a high oxygen content is not detrimental to fish, since both the young trout and perch lived in water containing almost saturation quantities of oxygen. Conditions presented in figure 1 and in table 3 indicate that the presence of free carbon di-oxide is necessary to support young fish life. In every test, whether oxygen be in excessive amounts or in reasonably normal quantities, fish living in water in the absence of free carbon di-oxide died and this was true over the entire range of temperature. This is strikingly noticed in the case of the yellow perch. After living in water containing free carbon di-oxide for 16 days, upon changing to the very slightly alkaline tap water they died in 48 hours. This factor would indicate also the possible reason for the high mortality among the fish brought

from Lewistown. Changing from their natural water, 3.2 parts per million carbon di-oxide, to one devoid of this life giving gas, they promptly succumbed. The data given in table 6 would indicate that older trout, 3 to 4 months, can live in slightly alkaline water for a short period. It is to be noted that the temperature of the water during this experiment was not so extremely low, being 42°F. to 46°F.

These conditions are true for fish life generally, for Wells (5) found that fish do not live well in alkaline water but become sluggish and inactive, neutrality being toxic to some species. He also found that fresh water fish select slightly acid water in preference to that with neutral or alkaline reaction.

Hall (2) in a study of white fish brings out the fact that neutrality is fatal to this species and alkaline water toxic. A high oxygen content will permit these fish to thrive in water with a greater concentration of hydrogen ion (acidity) than if a small amount is present. The statement is also made that a hydrogen ion concentration favorable for fertilization is too high for later development and that the optimum degree of acidity is gradually lowered as the embryo becomes older.

Heretofore it has been the general belief that excessive oxygen has been the cause of increased mortality among fish in very cold water. While this may be a contributing factor, the experimental evidence presented in this paper together with compiled supporting data, indicate that free carbon di-oxide, regardless of the oxygen concentration, is necessary in water for the sustenance of fish life.

This study was conducted in coöperation with Swepson Earle, Conservation Commissioner for Maryland and under the direction of James W. Armstrong, Filtration Engineer.

REFERENCES

(1) Gwynn, A. P.: Effect of Chemically Treated Water on Goldfish. Engineering Bull. No. 2, Maryland State Dept. of Health, 1925.

(2) Hall, Ada R.: Effect of Oxygen and Carbon Dioxide on the Development of White Fish. Ecology, 6, 104–16, 1925.

(3) Britton, S. W.: The Effects of Extreme Temperatures on Fish. Amer. Jour. Physiology, 67, 411–21, 1924.

(4) Coker, R. E.: The Hydrogen Ion Concentration and Fishes in Waters Tributary to the Catawba River, North Carolina. (With Supplemental Observations in Some Waters Off Cape Cod, Massachusetts.) Ecology, 6, 52–65, 1925.

(5) Wells, M. W.: The Reaction and Resistance of Fishes in their Natural Environment to Acidity, Alkalinity and Neutrality. Biol. Bull., 29, 221–257, 1925.

COMMENTS ON CHAPTER V, MANUAL OF WATER WORKS PRACTICE[1]

By C. M. Baker[2]

In discussing the Manual of Water Works Practice one needs first to state his conception of what it is, or what it should be. The writer assumes the manual to be a boiled down concise reference to modern water works practice, with only such discussion as necessary for clarity. This material, however, should be supplemented with references to detailed information.

In considering Chapter V with reference to quality of water supplies, assigned to the writer for comments; it would seem that the portion commencing on page 114 "Standards of Water Supply Quality" to "Report of Advisory Committee on Official Water Standards," page 123, might be omitted as obsolete and superfluous, and a brief connecting paragraph substituted. This material deals almost entirely with obsolete standards and might be confusing to the casual reader who uses the book primarily as a reference.

Appendix III commencing on page 136 is probably seldom applied in general water works practice, but since it is a part of the committee's report possibly should be retained. It should be pointed out, however, that a water supply is no better than its "weakest link" and therefore that a long series of analyses, although favorable as a whole, may warrant considering the supply unsatisfactory if there are times when polluted water finds its way to the consumers so as to affect the public health. For instance a cross connection with a polluted supply may pass for years without causing pollution, but when some foreign particle becomes lodged in it and conditions are such as to permit the polluted water to flow into the distribution system a serious outbreak of water-borne disease may result. Seasonal changes and storms may also cause periodical changes deleteriously affecting the quality of the supply.

[1] Presented before the Wisconsin Section meeting, October 13, 1927.

[2] Sanitary Engineer, Madison, Wis.

A few other minor comments might be made as follows:

Page 111, second and third lines from the bottom *"as albuminoid ammonia (or Kjeldahl nitrogen)."* This statement seems to indicate that Kjeldahl nitrogen is synonymous with albuminoid ammonia which, however, is not entirely correct. Kjeldahl indicates the total organic nitrogen, while albuminoid ammonia represents only a part, probably about one-half, of the total organic nitrogen.

Page 112. In the discussion regarding chlorides it would seem well to emphasize that these results are insignificant where there are mineral saline deposits or where the normal chlorine is unknown. In fact the writer finds chlorides of little value in interpreting analytical results in many sections of the country. In connection with turbidity it should be pointed out that a turbid water probably indicates a polluted water, since, if a water is turbid, the purification has either been defective, or, if untreated, there has probably been some unusual disturbance which may have carried pollution into the supply.

In general, it is believed that greater emphasis should be placed upon and more space devoted to the necessity and method of making sanitary surveys. Such surveys are necessary to locate potential sources of pollution such as cross connections and other defects, in order to make the necessary improvements before rather than after contamination of the supply.

DISCUSSION

DEEP WELL PRODUCTION LIMITED BY THE WATER IN THE STRATA

We have been very much interested in the paper by John W. Moore, published in the JOURNAL of December, 1927, under the title "The Economical Limit of Deep Well Production" in which he so clearly brings out the cause of limitation and the reason for deterioration of wells constructed in sand and gravel and sand formations.

Mr. Moore states, among other things,

> Wells penetrating water bearing sand and gravel in which the sand is very fine presents problems for which satisfactory solutions have not yet been offered and when properly solved will indicate the number of gallons per minute or the rate of pumping which such a well can be called upon to deliver safely without shortening its life or diminishing its usefulness.

The object of this discussion is to demonstrate that such a solution has been found and is in actual operation in the "Air Made Well" process.

The principal difference between this method and all other methods of well construction lies in the fact of the removal of all sand from the gravel around the wells, whether this gravel is artificially or naturally placed and its ability to continue to remove the sand and keep the gravel bed free.

Mr. Moore says, "Unfortunately all of the sand carried forward by the water does not pass through the screen into the well." Also, "The lodging of each grain of sand increases the difficulty and within a short period of time wells located in such sand and gravel strata build up a wall of sand around the screen through which the water passes with an ever diminishing volume until the usefulness of the well is at an end."

There is no question that this is exactly true and the deposit of a gravel wall around the screen will only delay this diminishing of volume unless a means is provided to remove the sand deposited in the gravel by the inflowing water.

In this process of making and operating wells with compressed air,

no screen is used, but a gravel retainer is installed with large openings whose function it is to hold back the gravel, but freely to admit the sand.

This process for making wells in sand, quick sand and in sand bearing gravel has passed the experimental stage and has demonstrated its superiority in a considerable number of wells in operation for several years.

The use of air is necessary not only in the making of these wells, but also in their continued operation to keep the gravel bed free from sand and to continue the replacement of sand by gravel during the life of the well.

Several of these wells have been in continued operation for several months at Amarillo, Texas. In the spring of 1927, during the construction of the air lift plant, it was decided to install a deep well turbine pump in one of the air made wells which had 150 yards of gravel deposited around the gravel container in the sand strata. This pump produced to start with 750 gallons per minute. At the end of six months the pump at the same speed was producing only 413 gallons per minute. This drop in production was due solely to the fact that the water flowing in one direction towards the well had gradually filled the large gravel bed with sand and retarded the inflow.

Four other wells of similar construction but operated with air had in three months increased from 1700 to 2082 gallons per minute with the same amount of air and with the water level higher in the wells than during the smaller flow.

The feature of wells constructed in this manner is that with use the production increases, if care is taken to replace the sand pumped out with gravel and the gravel bed is kept clean by back flushing.

By referring to figure 1, a ready understanding of the process may be secured. A sheath casing surrounding the regular well casing is driven down into the hardpan, effectively shutting off the sand until the well casing is placed, with the perforations located in the water bearing strata. Perforations of sufficient size are provided to admit the sand freely, but to hold back the gravel.

The air lift footpiece is then placed in the well casing with a sealed well top and valves on the discharge and air piping. These permit air pressure to be placed on the columns of water in the well to reverse the flow out through the perforations in the screen. Gravel of selected size is set between the sheath casing and the well casing and

held at a level above the bottom of the sheath. This sheath casing is then withdrawn gradually while back blowing is employed to stir up and pump out the sand, at the same time forcing the gravel to take its place. In this way a large bed of gravel is placed around

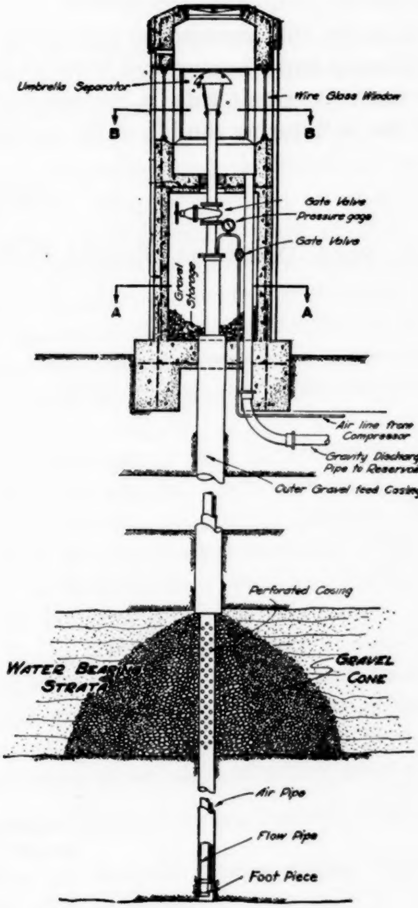


FIG. 1

the gravel retainer while the sheath casing is withdrawn to uncover the necessary amount of perforations to handle the flow.

After the well has been completed, a cement passage carries gravel to the space between the sheath and well casing so that as sand is

removed by continuous pumping it is replaced by the gravel and the entire bed is kept clean from sand by occasional back blowing.

There is no doubt that wells constructed in this manner can be pumped continuously to their full capacity, as the more sand is removed and replaced with gravel the freer the passage for the water to reach the well and the greater the inflow area.

It is evident therefore that continuous and heavy pumping with occasional back blowing and cleaning will improve production until the limit of the water bearing strata is reached and will maintain the usefulness of the well during the life of the material of which it is constructed.

JOHN OLIPHANT.[1]

[1] Chief Engineer, Pump Department, Sullivan Machinery Company, Chicago, Ill.

SOCIETY AFFAIRS

NORTH CAROLINA SECTION

The seventh annual convention of the North Carolina Section and the fifth annual Water Purification Conference were held at the Washington Duke Hotel, Durham, and at the University of North Carolina, Chapel Hill, on November 7, 8, and 9, 1927. The enthusiasm which has been characteristic of the Section's meetings since its institution was even more in evidence on this occasion, and the attendance reached the high-water mark of 260. Representatives were present from municipalities of practically every state east of the Mississippi, and seven state boards of health sent members of their sanitary engineering staffs to participate in the program. The exhibits of about 40 manufacturers were attractively arranged on the mezzanine floor of the Washington Duke, and evoked the greatest interest.

Innovations in the program were the inclusion of sewage disposal and stream pollution topics and the treatment of a limited number of important subjects by the symposium method. Vice-President C. E. Rhyne presided at the general meetings, while Chairman A. O. True had charge of the sessions of the Water Purification Conference. The Section was honored with the presence of James E. Gibson of Charleston, S. C., President of the parent association, who served as toastmaster at the barbecue, luncheon, and banquet, and brought a message of good will from the national organization.

Following registration on the opening day of the convention, the following papers were given, each of which drew a lively discussion:

1. "Advantage to Cities in Operating Combined Water and Power Plants," by M. Swartz.
2. "Economics of Elevated Storage versus Large-Size Distribution Mains," by J. O. Craig.
3. "The Advantages of the Two-Main System of Water Distribution," by Thos. F. Wolfe.
4. "Problems Arising from Impounded Water Supplies," by G. F. Catlett.

On the afternoon of the first day a 30 mile automobile trip was taken over picturesque country to inspect the new filtration plant of

the city of Durham, and the impounding reservoir, hydro-electric plant and raw water pumping station on Flat River. As a climax to the inspection trip, the city of Durham served an old-fashioned southern barbecue, with accessories to match, to the 260 visitors on banquet tables set up in the spacious hydro-electric plant. Dr. J. M. Manning, Mayor of Durham, welcomed the Section to the city, to which President J. E. Gibson responded on behalf of the local and national associations.

Following the barbecue dinner the party returned to the Washington Duke and viewed the following moving-picture program:

1. "Manufacture of Pipe for the Rio Claro Water Project, Sao Paulo, Brazil."
2. "Development of New Wells for the Kinston, N. C., Water Supply."
3. "Construction of Bee Tree Reservoir for the Asheville, N. C., Water Supply."

For luncheon the members and guests motored to Chapel Hill where they were entertained by the manufacturers at the Carolina Inn. The afternoon program was given in Phillips Hall, the engineering building of the University of North Carolina, and included the following papers:

1. "Filtration Improvements and Economics with Prechlorination," by J. S. Whitener.
2. "Correction of Red Water Troubles at Fayetteville," by J. L. Weathers.
3. "Experiences with Red Water at Southern Pines," by Cyrus Butler.
4. "Dissolved Iron and Manganese in Stored Water at Kernersville," by W. H. Weir.
5. "Notes on the Biology of Stored Waters of North Carolina" (Illustrated), by M. F. Trice.
6. "Water Plant Records," by J. K. Marquis.

On Tuesday morning November 8, the Water Purification Conference held a symposium on stored waters with the following papers and discussions:

1. "Water Supply Investigations in Venezuela" (Illustrated), by Thorndike Saville.
2. "Some of My Water Works Experiences," by J. D. Cochran.
3. "Recreational Uses of Water Supply Streams and Reservoirs," by W. E. Vest.
4. "Why Sewage Treatment," by H. G. Baity.
5. "Sewage Treatment Practice in Ohio," by F. H. Waring.

Following the program inspection tours were conducted through the University's water purification plant, the laboratories of sanitary engineering, and various other points of interest in Chapel Hill.

In the evening the annual association banquet was held at the Washington Duke, and was attended by two hundred members and guests. The dinner addresses and discussions were devoted to the subject of stream protection and conservation. Hon. Angus W. McLean, Governor of North Carolina, pointed to the necessity for a program of sanitary conservation of the streams of the state which will be preventive rather than remedial in its execution. Mr. W. L. Stevenson spoke on the subject "Waterway Sanitation," and explained the organization and work of the Sanitary Water Board of Pennsylvania. Mr. F. H. Waring told of Ohio's progress in the handling of stream pollution problems and the methods which have been employed to finance adequate sewage treatment facilities. Major Wade H. Phillips, Director of the Department of Conservation and Development, spoke on the recently organized stream pollution board in North Carolina, and outlined its policies and objectives.

The morning's program on November 9 was devoted to a symposium on sewage treatment. The following papers were presented:

1. "Types of Sewage Treatment Plants and Appliances," by C. W. Smedberg.
2. "Imhoff Tanks," by C. W. Sparmaker.
3. "Separate Sludge Digestion," by Geo. D. Norcom.
4. "Sewage Filters," by F. H. Waring.
5. "Activated Sludge,"—Moving Picture of the Milwaukee Sewage Treatment Works.
6. "Direct Oxidation," W. E. Thatcher.
7. "Correction of Odor Nuisances at Sewage Treatment Plants by Liquid Chlorine," by L. H. Enslow.
8. "Disposal of Industrial Sewage," by A. O. True.
9. "Laboratory Control of Sewage Treatment Processes," by G. F. Catlett.

The afternoon session of the third day was given over to the business meeting of the Section. Reports of the officers of the Section were heard, as were reports of the several standing and special committees. Resolutions were adopted expressing the gratitude of the Section to the city of Durham and its officials for their hospitality and entertainment, to the many out-of-state visitors for their splendid contributions to the program, to the manufacturers who assisted so materially in the success of the convention, and to the press representatives whose publicity carried to the people of the state

an interpretation of the vital enterprises in which the Section is engaged.

The Section expressed itself as being favorable to the policy of continuing the discussion of sewage treatment and stream pollution subjects in the program of the annual conventions, and considered this year's experiment a great success. In line with this action, it was voted to change the name of the Water Purification Conference to "Conference on Water Purification and Sewage Treatment." The matter of joining the proposed national federation for the discussion and publication of sewage papers was discussed at length, the Section expressing itself as favorable to the plan and authorizing the Executive Committee to take whatever action it deems proper in such an affiliation.

It was voted to fix the time of the annual convention on the first Monday, Tuesday and Wednesday of November of each year, the Executive Committee to have the power to change the date in case it is impossible for any reason to hold the meeting on these dates.

By a close vote Raleigh was chosen as the 1928 convention city, with headquarters at the Sir Walter Hotel.

The following officers were elected for the ensuing year: President, C. G. Logan; Vice-President, J. D. Cochran; Secretary-Treasurer, H. G. Baity; Editor, E. G. McConnell.

The Conference on Water Purification and Sewage Treatment selected as its officers for the year: Chairman; J. S. Whitener; Secretary, G. F. Catlett.

Following the adjournment of the business meeting an inspection trip was made to the experimental plant which is being operated jointly by the city of Durham and the University of North Carolina to determine suitable methods of handling Durham's problem of treatment of combined sewage and textile wastes.

H. G. Baity,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Settling Basin for Water Works of Lawrence, Kansas. Wynkoop Kiersted. Eng. News-Rec., 99: 65, 1927. Illustrated description of the recently completed settling basin at Lawrence which consists of 4 compartments for (1) natural sedimentation, (2) mixing and application of chemicals, (3) chem. reaction, and (4) final sedimentation, the retention periods at the rated capacity of 3 m.g.d. being 2 hours, 21 minutes, ½ hour, and 3½ hours, respectively. The water is delivered into the coagulation compartment through a series of vertical slots 5 feet high, with a width beveled outward from ½ to 2 inches. The preliminary and coagulation basins are double hopper bottomed, provision being made for drawing off sludge without disturbing main valve.—*R. E. Thompson (Courtesy Chem. Abst.).*

Foundation Grouting at Camarasa Dam. Eng. News-Rec., 99: 105, July 21, 1927. This 300-foot structure near Barcelona, Spain, highest dam in Europe, rests on fissured rock containing solution cavities down to considerable depth. Grouting will be carried out to depth of 400 or 500 feet below base of dam; combination of filling with inert materials, cement grouting and asphalt grouting will probably be used. Grout holes are being drilled through dam from top.—*R. E. Thompson.*

Building a High Concrete Arch Dam in a Narrow Canyon. Eng. News-Rec., 99: 168–70, August 4, 1927. Illustrated description of construction of Pacoima Dam being built on Pacoima Creek 4 miles above San Fernando, Cal., as part of Los Angeles County flood control project. Dam will be 385 feet in height, with crest length of 600 feet. Gorge at dam site is only 40 feet wide at stream bed level. Dam is constant-angle arch and will contain 225,000 cubic yards of concrete.—*R. E. Thompson.*

Fatigue Endurance of Cast Iron. H. F. Moore and S. W. Lyon. Eng. News-Rec., 99: 94–5, July 21, 1927.—*R. E. Thompson.*

---

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

English Filter Plant Recovers Wash Water Wasted. Eng. News-Rec., **99:** 93, July 21, 1927. From (London) Engineering, 630, May 27, 1927. Wash water at Sandsfield filtration plant is collected in tanks and returned to raw water after sludge has settled. Sludge is pressed to remove moisture. Actual observations over period of month showed percentage of wash water wasted to be 0.0304. Normal wash water waste in British plants is 1–2 per cent.—*R. E. Thompson.*

Pondage Important Factor in Spillway Design. Melvin D. Casler. Eng. News-Rec., **99:** 133–6, July 28, 1927. Mathematical discussion of spillway design.—*R. E. Thompson.*

Concrete Improved by the Use of Diatomite. V. L. Eardley-Wilmot. Cont. Rec. Eng. Rev., **41:** 331–2, 1927. The addition of a small percentage of diatomite to concrete increases its workability and results in a dense, uniform and smooth product. The compressive strength is increased as much as 15 per cent and the concrete is more waterproof and resistant to the action of $MgSO_4$. The average addition is about 3 per cent; the leaner the mix the greater should be the proportion of diatomite. For waterproofing, the best results are obtained by addition of 5 to 6 per cent.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Building a 200-Mile Oil Pipe Line. Eng. News-Rec., **98:** 890–7, June 2, 1927. Detailed illustrated description of 200-mile oil pipe line being constructed by Prairie Pipe Line Company in Texas. Line is of 8-inch steel pipe and all joints are welded. Before applying protective covering pipe was thoroughly cleaned with self-propelled machine consisting of automobile engine connected to roller of small knife edges which revolves about pipe. Directly behind cutters a wire brush revolves, removing loosened scale.—*R. E. Thompson.*

Typhoid Outbreak at Watseka, Ill. Eng. News-Rec., **99:** 53, July 14, 1927. City water supply, repeatedly classed as unsafe, is considered, though not definitely proved, cause of typhoid epidemic at Watseka, Ill., in October and November, 1926. In population of 5000 with 750 water users there were 34 cases and 3 deaths. Since June 1919, periodical examinations have shown city water from two drilled wells, pumped by direct suction, to be of doubtful sanitary quality and in some cases unsafe. These conditions had been reported to city authorities, with frequent recommendations for continuous chlorination. Water had been prohibited for use on trains on account of failure to meet requirements of United States Public Health Service. Chlorinator was installed in November, 1926, but was not made use of until after epidemic was well under way.—*R. E. Thompson.*

Quality Design and Control of Concrete. Joseph A. Kitts. Eng. News-Rec., **99:** 232–3, 1927. Essential control measures for producing quality concrete with economy are outlined.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Construction and Inspection of Concrete. John Empey. Cont. Rec. Eng. Rev., **41**: 265–6, March 16, 1927. Practical hints for making good concrete. —*R. E. Thompson.*

Continuous Inspection Minimizes Water Waste at Madison, Wis. L. A. Smith. Eng. News-Rec., **98**: 875, May 26, 1927. Continuous inspection of water distribution system by meter readers has reduced water unaccounted for in Madison from 23.2 per cent in 1918 to 6.7 per cent in 1925. Meter readers can carry on this additional work without decreasing reading efficiency.—*R. E. Thompson.*

Influence of the Water-Cement Ratio on the Strength of Concrete. F. R. McMillan. Cont. Rec. Eng. Rev., **41**: 554–5, 1927. Experiments are described which show that concrete of uniform strength of any desired workability can be obtained by keeping water-cement ratio constant and varying the mix, whereas workability is only obtained at the expense of quality when additional water is employed.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Hot Water Pipes Freeze More Quickly Than Cold Ones—Why? Cont. Rec. Eng. Rev., **41**: 439–40, May 4, 1927. Phenomenon is attributed by Leon McCulloch to greater circulation in cold water pipes due to decrease in density below 39°F.—*R. E. Thompson.*

Estimating Quantities of Materials in Concrete. Cont. Rec. Eng. Rev., **41**: 437, May 4, 1927. Method determining quantity of materials required for unit volume of concrete of any mix, based on fact that volume of concrete, when plastic, is equal to absolute volume of aggregate plus absolute volume of cement plus volume of water.—*R. E. Thompson.*

Air Tools for Trench and Tunnel Excavation. Cont. Rec. Eng. Rev., **41**: 559–60, 1927. Operation of pneumatic tools, with cost data, discussed.—*R. E. Thompson.*

River Control in the Palo Verde Valley. Spencer E. Webb. Eng. News-Rec., **99**: 226–8, August 11, 1927. Details given of river control work of Palo Verde Irrigation District on lower Colorado. Method devised for causing formation of dams and spur dikes, consisting of placing steel equilateral pyramids constructed of scrap railroad rails upon which drift pack collects, is described.—*R. E. Thompson.*

Progress of Cascade Tunnel, Great Northern Railroad. Eng. News-Rec., **99**: 224–5, August 11, 1927.—*R. E. Thompson.*

Solid Phases Developed in Boiler Waters. R. E. Hall and H. E. Merwin. Am. Inst. Chem. Eng., **16**: Part II, 91–117, 1924. From Chem. Abst., **20**: 3323, October 20, 1926. Deposition responsible for growth of adherent scale occurs in situ. If in solubility curve of a substance the value of dS/dT is negative, adherent scale is result; but only independent particles will form

if it is positive. Elimination of adherent scale growth is attained by so adjusting concentrations in boiler that dS/dT for solid phases in equilibrium is positive. Concentrations of calcium sulfate and calcium carbonate, representing adherent and free scales respectively, can be adjusted so that very little adherent scale is formed; ratio of concentration of CO_3 to that of SO_4 should be greater than $\frac{1}{8}$ of ratio of solubility product of calcium carbonate to that of calcium sulfate at temperature of boiler water.—*R. E. Thompson.*

Removing and Preventing the Formation of Boiler Scale by Ionization Phenomena. F. Venneman. Mon. papeterie belge, **6**: 229–33, 1926. From Chem. Abst., **20**: 3323, October 20, 1926. Formation of hard adherent scale in boilers is due to porosity of steel boiler shell which firmly holds material deposited from water, and to orientation of deposit in direction at right angles to shell. Formation of scale can be prevented, and scale already formed can be softened and removed by means of electric current insufficient to cause electrolytic decomposition of water or of dissolved salts. In De Naeyer boiler with heating surface of 250 square meters and evaporation of 7 cubic meters per hour a layer of scale 6 to 8 mm. thick was completely removed in few months with input of 46 watts and no further scale was observed, even when water in boiler reached hardness of 400.—*R. E. Thompson.*

Paint and Varnish as Enemies of Corrosion. E. B. Timmerman. Can. Chem. Met., **10**: 205–7, 1926. From Chem. Abst., **20**: 3353, October 20, 1926. General discussion of factors affecting life of paint and varnish.—*R. E. Thompson.*

Makeup of Breached Levees Given in Report by Colonel (Chas. L.) Potter. Eng. News-Rec., **99**: 300–1, August 25, 1927. Data given on construction of Mississippi River levees which failed during recent flood, character of material and general condition.—*R. E. Thompson.*

High Density of Snow Accelerates Its Melting and Runoff. J. E. Church, Jr. Eng. News-Rec., **99**: 553, October 6, 1927. Data given on relation of density, etc., of snow to rapidity of melting and runoff. Investigations have shown that high density accelerates melting, contrary to former popular belief.—*R. E. Thompson.*

Determination of Carbonic Acid in Small Quantities of Sea Water and Other Fluids by Means of Krogh's Micro-Respiration Apparatus. Torbjørn Gaarder. Physiol. Papers dedicated to August Krogh 1926, 47–79. From Chem. Abst. **20**: 3274, October 20, 1926. Sample is placed in closed air-filled container and carbon dioxide liberated by addition of strong acid and distributed between fluid and air in vessel by agitating. Increase in pressure, determined by manometer, is measure of carbon dioxide. Manometer must be very sensitive and Krogh's micro-respiration apparatus is found to be suitable. Carbon dioxide content of 2-cc. sample of an aqueous solution may be determined with accuracy of ±0.8 cm.—*R. E. Thompson.*

A New Precise Method of Measuring Small Quantities of Carbon Dioxide. Shigeru Nishi. Acta Scholae Medicinalis, **7**: 263–70, 1925. From Chem. Abst., **20**: 3274, October 20, 1926. Method is similar to that of Warburg (C. A. **4**: 597) except that barium carbonate precipitate is removed by filtration out of contact with carbon dioxide of air (cf. C. A. **19**: 3443).—*R. E. Thompson.*

Apparatus for Deaerating Water. G. H. Gibson. U. S. 1,596,423, August 17. From Chem. Abst., **20**: 3324,October 20, 1926.—*R. E. Thompson.*

The Determination of Fixed and Free Carbonic Acid in Water. Critical Study. V. Rodt. Zement, **14**: 206–9, 249–53, 1925. From Chem. Abst., **20**: 3760, November 20, 1926. Determination of carbonate by titration with 0.1 N acid using methyl orange gives good results provided liberated carbon dioxide is expelled by boiling. Determination of free carbon dioxide by addition of excess barium hydroxide and back titration is unreliable since increasing the excess of barium hydroxide gives higher results. Fair results are obtained with water largely free from organic acids by precipitating with barium hydroxide and, without filtering, adding hydrochloric acid and weighing evolved carbon dioxide after absorption in suitable train. To determine active carbon dioxide, sample was agitated gently for 24 hours with excess of finely pulverized marble, filtered and added carbonate content titrated with acid.—*R. E. Thompson.*

Solving Some Unusual Problems in Sand Filtration. M. E. Dice. Chem. Met. Eng., **33**: 529, 1926. **High-Pressure Filtration of Softened Water.** L. H. Biggar. Power Plant Eng., **30**: 1050, 1926. From Chem. Abst., **20**: 3760, November 20, 1926. Air bubbled through sand make craters into which precipitate works. Minute air bubbles in water also prevent perfect filtration. By increasing head on filter to at least 13 feet and by using fine sand of low uniformity coefficient these obstacles are overcome. Formulas for determining necessary head and rate of flow given.—*R. E. Thompson.*

High-Pressure Filtration of Softened Water. L. H. Biggar. Power Plant Eng., **30**: 1050, 1926. From Chem. Abst., **20**: 3760, November 20, 1926. Penetration of sand by precipitate occurred when head was less than 13 feet. From 13 to 33 feet no penetration occurred. Believed that at low heads air works up through sand forming craters in surface into which precipitate gradually works. Fine sand of low coefficient of uniformity which gives high porosity should be used.—*R. E. Thompson.*

The Use of Water in Baking. F. P. Siebel, Jr. The Northwestern Miller, **147**: 748, 1926. From Chem. Abst., **20**: 3320, October 20, 1926. Medium permanently hard water strengthens or toughens gluten, causing it to retain carbon dioxide better, producing finer-grained structure. Very hard waters retard fermentation, necessitating employment of longer fermentation time, higher temperatures, or increased amount of yeast. Soft water softens gluten,

causing dough to be sticky and resulting bread soggy. Waters which are very soft should never be used without treatment.—*R. E. Thompson.*

Organic Content of Lake Water. E. A. Birge and Chancey Juday. Proc. Nat. Acad. Sci., **12**: 515–9, 1926. From Chem. Abst., **20**: 3323, October 20, 1926. Data on organic content of Lake Mendota.—*R. E. Thompson.*

The Chemical Control of Rapid Filtration Plants. F. Egger. Z. angew. Chem., **39**: 962–4, 1926. From Chem. Abst., **20**: 3323, October 20, 1926. Results obtained with Stuttgart plant on river (Neckar) and lake water. It was found practical to always add about 20 p.p.m. aluminum sulfate and allow 2½-hour sedimentation period. Raw and filtered water had permanganate figures of 15.5 and 9.4 p.p.m. respectively. Bacterial removal was about 90 per cent. Subsequent chlorination was always necessary. Details of chemical control discussed in original (cf. Egger, C. A. **19**: 2383; **20**: 2216).—*R. E. Thompson.*

Properties of Doucil, a New Base-Exchange Silicate. J. G. Vail. Am. Inst. Chem. Eng., **16**: Part II, 119–29, 1924. From Chem. Abst., **20**: 3324, October 20, 1926. Doucil ($Na_2O \cdot Al_2O_3 \cdot 5SiO_2$) is prepared by complete gelation of solution made from sodium silicate and sodium aluminate. Its porous structure exposes a great surface. One cubic foot contains 25 pounds anhydrous silicate, capable of adsorbing 12,500 grains calcium carbonate. Waters containing hydrogen sulfide deposit sulfur on grains, clogging capillary system. Oils or suspended matter also interfere. Material must be kept moist and cannot be cleaned with acid.—*R. E. Thompson.*

Water Separator for High-Pressure Steam. Th. Hoffmann. Chem. App., **13**: 188–9, 1926. From Chem. Abst., **20**: 3363, November 10, 1926.—*R. E. Thompson.*

Corrosion of Iron Pipes by Water in Economizers. Apparatebau, **38**: 210–11, 1926. From Chem. Abst., **20**: 3363, November 10, 1926.—*R. E. Thompson.*

The Precipitation of Aluminum as Hydroxide by Means of Ammonia. Gerhart Jander and Otto Ruperti. Z. anorg. allgem. Chem., **153**: 253–9, 1926. From Chem. Abst., **20**: 3371, November 10, 1926. To obtain best results in estimation of aluminum by precipitation as aluminum hydroxide with ammonium hydroxide the reaction mixture should contain no excess of free ammonium hydroxide, very little ammonium salts, and should be filtered cold through a membrane filter. The solubility of aluminum hydroxide in water (solution prepared by action of aluminum amalgam on pure water) was 0.6 and 1.2 p.p.m. in cold and hot solution respectively. Ammonium hydroxide increases solubility of alumina enormously and its salts exert much smaller influence in same direction.—*R. E. Thompson.*

Treatment of Waste Acid Waters from Metallurgical Plants. Armand Clause. Rev. chim. ind., **35**: 237–40, 1926. From Chem. Abst., **20**: 3440,

November 10, 1926. Brief discussion of advantages of recovering acid and ferrous sulfate.—*R. E. Thompson.*

Eighteen Months' Operation of the World's Largest Filtration Plant. WILLIAM M. WALLACE. American City, **35**: 1, 42, July, 1926. Describes and explains the difficulties encountered, experimental work performed, and the improvements made in the operation of the world's largest filtration plant. At the beginning of the plant's operation the coagulant, aluminum sulphate, was introduced at the initial point of the mixing chamber. The change of the point of application to the effluent end of the intake tunnel provided better mixing and longer filter service. No apparent difference in flocculation. Limited filtered water storage during 1925 necessitated the operation of the filters at a high rate, resulting in a shorter filter service and low bacteriological efficiency. Provision has been made for the construction of an additional filtered water reservoir of 20 million gallons. The methods and results of experimental studies on the coagulation basins are outlined. The method of treatment employed for the removal of "mud balls" from the filters is given. The cause for the formation of the "mud balls" was later found to be due to the large distance from the level of the sand in the filters to the crest of the wash water troughs and air binding. No "mud balls" have formed since adding an additional 10 inches of sand to the filters and elimination of air pockets.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Features of the Miami Water Softening Plant. L. R. HOWSON. American City, **35**: 1, 5, July, 1926. The softening plant completed in the summer of 1925 consisted of chemical house with equipment, mixing tanks, Dorr clarifier, sedimentation basin, settling basin, carbonating basin, a 10 million gallon rapid sand filtration plant and pumping equipment of 40 million gallons per day. In September, 1925, it was decided to increase the capacity to 20 million gallons per day. Certain changes from the first plans were made in the equipment and operation of the plant. This construction is practically complete now.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Scituate Water-Supply Project for Providence, R. I. Anon. American City, **35**: 3, 309, September, 1926. The new Providence water supply, known as the Scituate Project, will, it is estimated, furnish an adequate supply for the city until 1970. The new storage reservoir furnishes water by gravity and has a capacity of 37,000 million gallons. It has a watershed of 92.8 square miles and will readily furnish 85 million gallons per day. The building of the reservoir involved the construction of 26 miles of new highway to replace 36 miles abandoned, and the removal of the remains from many small cemeteries to a new cemetery with 1549 graves. The construction included a dam 3200 feet long with an earth core; purification works with aerators, circular coagulant-mixing well with tangential entering stream, basins and rapid sand filters; a seven mile aqueduct consisting of several miles of 7½-foot reinforced concrete conduit, 3½ miles of concrete lined rock tunnel and 2 miles of 66-inch steel pipe. Changes will also be required in the distribution system.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

From the Old Oaken Bucket to a Modern Safe Water Supply. J. A. Jensen. American City, 35: 3, 323, September, 1926. Brief review of advance in water works practice during last thirty years. Indicates clearly broad and complicated field of endeavor in water works business, and the need for properly qualified versatile men capable of keeping step with the advancement and progress of the art.—*A. W. Blohm* (*Courtesy U. S. P.·H. Eng. Abst.*).

The Orthotolidine Reagent for Free Chlorine in Water. Emery J. Theriault. Public Health Reports, 42: 10, 668, March 11, 1927. Orthotolidine was first proposed by Phelps (1909) as a qualitative test for the detection of minute amounts of free chlorine and hypochlorites. Directions for the preparation of orthotolidine reagent is given. The desired yellowish colorations will be obtained when 1 cc. of the reagent is added to 10 cc. of a chlorine-containing sample, provided that its volumetric alkalinity does not exceed 400 or 500 p.p.m. and that its chlorine content is less than 4 or 5 p.p.m. When volumetric alkalinity is too high, bluish-green colorations are obtained, and in solutions which are distinctly acid, orange-red colorations may result in the presence of large amounts of free chlorine. The reddish hues tend to become lighter in color as the amount of chlorine increased and if sufficient excess of free chlorine is added, yellowish colorations may eventually be again obtained. At higher pH values, almost any desired shade of color may be obtained by varying the proportion of reagent added to the amount of chlorine present. It is noted that the sensitiveness to free chlorine of the reagents prepared with four different brands of orthotolidine was very much the same regardless of color of the reagent or purity of the chemical.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Improved Micro Kjeldahl Ammonia Distillation Apparatus. George Kemmerer and L. T. Hallett. Ind. Eng. Chem., 19: 1295, 1927. A distillation apparatus has been devised for obtaining small amount of ammonia from the total nitrogen in residue from water. The ammonia so obtained is estimated either by nesslerizing or by absorption in acid. Extremely accurate analytical results are given.—*Edward S. Hopkins.*

Extending the Life of Chemical Glassware. J. T. Littleton, Jr. and G. A. Dasney. Ind. Eng. Chem., 19: 1271, 1927. If caution is exercised in the heating of laboratory glassware many incidents of subsequent breakage, when used in other tests, will be avoided.—*Edward S. Hopkins.*

Large Capacity Incubators. F. A. McDermott. Ind. Eng. Chem., 19: 1274, 1927. A description and diagram of an electric thermo-regulator is given.—*Edward S. Hopkins.*

Water Purification by Electroosmosis. A. S. Behrman. Ind. Eng. Chem., 19: 1229, 1927. This process produces a "distilled water without distillation with certain limitations" and consists essentially in electrolyzing the water, passing it through a series of cells grouped together like a filter press; colloidal

particles and a major portion of the electrolyte being removed in the last cells of the group under the influence of higher voltage. It is claimed that effluent water equal in purity to distilled water can be produced by this process and plants operating in Austria and Germany substantiate this claim. Water prepared in this manner may be used in laboratory testing, storage batteries, etc., since it has the purity of distilled water. From 75 to 95 kw. hours per 1000 gallons of water are required to produce an effluent equal to distilled water. Plant development of the method is planned for the future.—*Edward S. Hopkins.*

The Hydraulic Design of Flume and Siphon Transitions. JULIAN HINDS. Proc. Amer. Soc. Civ. Eng., **53**: 8, 1805–41, October, 1927. For structures involving velocities in excess of 6 to 8 feet per second, careful detailed computations for transitions must be made. If not proportioned in accordance with the hydraulic requirements the design may prove seriously defective. The design of an inlet should provide for a drop in the water surface sufficient to produce the required increase in velocity and to overcome friction and entrance losses. At an outlet the water will rise theoretically a vertical distance equal to the reduction in velocity head. The actual rise is less than the theoretical, because of frictional and outlet losses. A number of typical flume inlets and outlets are shown. Tables are also given for computing these inlets and outlets.—*John R. Baylis.*

Water-Power Appraisals. WILLIAM H. CUSHMAN. Proc. Amer. Soc. Civ. Eng., **53**: 8, 1843–50, October, 1927. This paper calls attention to the lack of uniformity in the methods now used in appraising water-power property. —*John R. Baylis.*

Side Spillways for Regulating Diversion Canals. W. H. R. NIMMO. Proc. Amer. Soc. Civ. Eng., **53**: 8, 1878–92, October, 1927. The author presents the theory developed in the design of a side spillway for regulating the flow in a diversion channel on the Upper Ouse River in Tasmania. Twenty-three formulas are given. Where some type of automatic gate is not suitable side spillways may prove practical.—*John R. Baylis.*

A Graphical Method for Determining the Stresses in Circular Arches under Normal Load by the Cain Formulas. F. H. FOWLER. Proc. Amer. Soc. Civ. Eng., **53**: 8, 1893–1917, October, 1927. A series of curves for determining the stresses, in pounds per square inch, at the extrados and intrados of crown and abutments of circular arches under normal loads are given. The diagrams are presented with the hopes of assisting those using CAIN's method of analysis.—*John R. Baylis.*

Advances in Waterway Engineering during a Half Century. W. M. BLACK. Proc. Amer. Soc. Civ. Eng., **53**: 8, 1937–59, October, 1927. A review of the progress of waterways engineering in the U. S. for the past half century.—*John R. Baylis.*

The Head-Works of the Imperial Canal. C. E. Grunsky. Proc. Amer. Soc. Civ. Eng., **53**: 9, 2184–7, November, 1927. The gate is a structure 600 feet long with 75 openings between piers. Some 400 feet of the structure is in fine sand, which has been prevented from washing from under the gate by placing upon it the floor of the structure, heavily weighted by a box of sand. There has been no settling during the eight years since its completion. —*John R. Baylis.*

Baffle-Pier Experiments on Models of Pit River Dams. I. C. Steel and R. A. Monroe. Proc. Amer. Soc. Civ. Eng., **53**: 9, 2189–2218, November, 1927. The authors present the results obtained from a series of experiments made on one-twentieth scale models of the diversion dams for hydro-electric projects of the Pacific Gas and Electric Company. The object was to determine the most satisfactory means of controlling or destroying the energy from the over-pour water at the foot of the dams in order to prevent erosion of the down-stream banks and bed of the stream. The most satisfactory results were obtained by the use of two rows of baffle-piers resting on a concrete apron below the bucket of the dam, the upper row of piers being truncated prisms serving as splitters and the lower row having curved up-stream faces to act as deflectors and baffles.—*John R. Baylis.*

Maximum Flood Discharge in San Joaquin Valley, California. Oren Reed. Proc. Amer. Soc. Civ. Eng., **53**: 9, 2220–44, November, 1927. An attempt was made to estimate flood discharge for one river from the known discharges of rivers of the same meteorological province. Long-term records are required to estimate the extreme flood to be expected.—*John R. Baylis.*

The Science of Foundations—Its Present and Future. Charles Terzaghi. Proc. Amer. Soc. Civ. Eng., **53**: 9, 2263–94, November, 1927. The author reviews the present state of the science of foundations. The principal shortcomings were found to be (1) the practice of selecting the admissible soil pressure regardless of the area covered by the individual foundations and irrespective of the maximum differential settlement that the structure can stand without injury, (2) the practice of computing the bearing capacity of the piles by the *Engineering News* formula regardless of the character of the soil, and (3) the practice of considering the bearing power of the individual as a sufficient guaranty that the bearing capacity of the entire foundation will be adequate. The author explains the inconsistencies that are often experienced in the attempt to interpret the results of load tests for designing purposes.—*John R. Baylis.*

Chlorine Studies and Some Observations on Taste-Producing Substances in Water and the Factors Involved in Treatment by the Super- and De-chlorination Method. Norman J. Howard and Rudolph E. Thompson. Jour. New Eng. Water Works Association, **41**: 1, 59, March, 1927. Results of three months experimentation treatment in Toronto effective and resulted in improved conditions. When taste occurred four times during period, traced to insufficient chlorine doses partly due to lacking equipment and rapid

changes in quality of raw water. Efforts to economize in chlorine application make treatment ineffective and may even accentuate taste conditions. Biological activity in warm water helps in taste elimination, permitting reduced application of chlorine. For effectiveness of superchlorination treatment under cold water conditions 2.0 p.p.m. chlorine must be applied to mechanically filtered and 1.5 p.p.m. to slow sand filtered waters. Mixing waters containing different quantities of chlorine inadvisable. Found desirable to remove all residual chlorine to insure absence of taste at distant distributing points during periods when water known to contain taste-producing substances. Improvement in maintaining pressure of liquid sulphur dioxide under high discharge conditions brought about by placing steam coils between cylinders.—*Carl Speer, Jr.*

Mechanically Cleaned Sedimentation Basins for Water Works. EDMUND B. BESSELIEVRE. Jour. New Eng. Water Works Association, **41**: 1, 52, March, 1927. Self-cleaning unit comprises simple rectangular concrete basin, sides approximately of equal length; inflow over entire length of one side, discharge over weirs the entire length of the opposite side. Basin of sufficient volume for desired theoretical retention. Provision made against cross currents and scum. Bottom of tank slopes to sludge cone. Unit equipped with mechanism to collect settled solids and carry to central cone. Clarifier mechanism moves very slowly and produces sludge of greater density than sludge of old method. Equipped with automatic safety switches to guard against undue load, overloading, foreign objects. Tried out in several cities with good results.—*Carl Speer, Jr.*

Effect of Cement Lined Pipes Upon the Quality of the Water Supplied. BURTON G. PHILBRICK. Jour. New Eng. Water Works Association, **41**: 2, 94, June, 1927. A consumer found scum on water (hitherto clear). Source of trouble at first not discoverable. Later seemed related to cement lined pipe. One case of increased hardness in water from cement lined pipe indicative there may be more. Worth investigation.—*Carl Speer, Jr.*

Combining Well and Water Supplies. WYNKOOP KIERSTED. Water Works Eng., p. 1059, July 20, 1927. Amarillo, Texas, population 50,000. City reinforcing the present distribution system and constructing a new water supply works. Development comprises drilling of seven wells of 500 g.p.m. each, construction of an earth dam impounding over 1600 million gallons, a well water reservoir and pumping station at the dam. Total available ground water supply estimated at 7 million gallons per day and the impounded supply from a catchment area of about 400 square miles at 3 million gallons per day. Wells to be from 1000 to 1500 feet apart with average depth of 200 feet. Strainer section located in permanent casing so as to reach to bottom of the water bearing sand. Sealing of strainers by sand avoided by back blowing. Water pumped to Amarillo through 30-inch lead jointed cast iron pipe 83,000 feet long; three surge tanks six feet inside diameter and relief valves placed along line.—*Carl Speer, Jr.*

Soil Corrosion and Its Effect upon Piping as Shown by the Tests of the United States Bureau of Standards. John D. Capron. Jour. New Eng. Water Works Association, **41**: 2, 81, June, 1927. Forty-six soils in 32 widely separated localities selected for experimental work, together with the common commercial pipe materials, including varieties of bare iron and steel pipe, non-ferrous metals, bituminous coatings, galvanized pipes, sheets with six weights of coating, and lead and aluminum coatings. In any one soil, type of corrosion similar in all rolled materials. In different soils, nature of corrosion on same materials differs materially. Specimens buried four years. Experiment so far shows (1) character of soil rather than type of material plays large part in earlier stages of corrosion of buried pipe; (2) no definite relation between soil characteristics and corrosion, although some soils more corrosive than others. Result hoped for from investigation to forecast life of pipe line in a particular soil and provide for its protection. Information on causes and prevention of soil corrosion will help solve problem of tuberculation in New England.—*Carl Speer, Jr.*

Effect of Pipes of Different Metals upon the Quality of Water Supplies. H. W. Clark. Jour. New Eng. Water Works Association, **41**: 1, 31, March, 1927. Whatever pipe used, a certain amount of metal is taken into solution by water. Amount varies under different conditions and with different waters. Galvanizing iron pipe largely prevents absorption of iron, but zinc is taken in while galvanizing lasts. Little tin absorbed from tin pipes. Brass pipes yield much zinc but minute amounts of copper. Copper pipes yield copper in same amount as brass pipes, but zinc not involved. Descriptive figures and tables given. Water considered perfectly wholesome if one day's supply does not contain more than 0.1 of a grain per Imperial gallon or 0.14 part in 100,000.—*Carl Speer, Jr.*

Flow of Water Through Porous Concrete. W. G. Kirchoffer. Water Works, **66**: 351–4, 1927. Porous concrete slabs made of permeable gravel concrete cores surrounded by watertight shells of 1:2 mortar were tested for loss of head under various discharges. These cores were made of gravel (1) passed over a 1-inch round sieve and (2) passing through a 1-inch but held on a $\frac{3}{4}$-inch round sieve and were 6 inches thick. The grout mortar contained 1 part portland cement 1 part sand and 30 per cent water. The loss of head in average porous concrete 1 square foot in area varied from 0.018 foot for 5 gallons per minute to 1.376 feet for 70 gallons per minute. Graphs and tables showing the results of the tests are given. Slabs of this porous concrete have given good results in filter bottoms and in wells in place of well screens. —*C. C. Ruchhoft.*

Erecting New Water Intake for Chicago System. Anon. Water Works, **66**: 395–6, 1927. The steel structure of this intake is being built on shore. The structure consists of two concentric rings 45 feet high, the inner one 45 feet and the outer one 90 feet in diameter and contains 8 steel ports. The ports are being bulkheaded and additional buoyancy is secured by 16 buoyancy

chambers. This structure will be towed to the site of the new crib, sunk, filled with concrete, and connected to the new tunnel.—*C. C. Ruchhoft.*

Traveling Water Screens. F. S. Van Bergen. Water Works, **66**: 438–9, 1927. The pumping station for the new Fridley Filtration Plant of Minneapolis is equipped with two vertical Rex traveling water screens. These screens are designed for 25.5 foot centers, carry 8 foot baskets made of No. 12 B. & S. gauge copper wire, and each has a capacity of 40,000 gallons of water per minute.—*C. C. Ruchhoft.*

Two New England Purification Plants. Anon. Public Works, **58**: 321–6, 1927. The plant at Meriden, Conn., with a capacity of 4 million gallons per day will include an aërator, coagulation basin, six rapid sand filters, and chlorinating equipment. The Wallingford, Conn., plant will provide aëration, filtration, and chlorination for a 2 million gallon per day supply taken from the Pine river.—*C. C. Ruchhoft.*

The Sao Paulo Aqueduct. Anon. Public Works, **58**: 451–2, 1927; Water Works, **66**: 489–90, 1927. The aqueduct, which is 48 miles long, will bring 53 million gallons of water per day from the Rio Clara basin located in a sparsely settled mountainous region to the 800,000 inhabitants of the city of Sao Paulo. The aqueduct has 15 miles of pressure pipe made of $\frac{7}{16}$-inch Armco ingot iron plate, 71 inches in diameter, 5 miles of pressure pipe 98 inches in diameter of $\frac{1}{2}$-inch plate, and the remainder of reinforced concrete. There will be about 50 tunnels on the line of the aqueduct and the longest of these will be about 0.9 miles. All curves are laid out on a 328 foot radius so that the same forms can be used.—*C. C. Ruchhoft.*

Constructing a Submarine Pipe Line. M. M. O'Shaughnessy. Water Works, **66**: 440–1, 1927. The method of laying 3165 feet of 42-inch siphon for the Bay Development Hetch Hetchy Water Supply Project of San Francisco, Cal., is described. Two hundred and sixty-three pieces of flexible joint pipe 2 inches thick in 12-foot laying lengths, each weighing about 6.5 tons, and 20 special pieces were used for the two siphons and were laid in water ranging in depth from 0 to 73 feet.—*C. C. Ruchhoft.*

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION

President

JAMES E. GIBSON, Manager and Engineer, Water Department, 14 George St., Charleston, S. C.

Vice-President

WILLIAM W. BRUSH, Chief Engineer, Department of Water Supply, Gas and Electricity, Municipal Bldg., New York, N. Y.

Treasurer

GEORGE C. GENSHEIMER, Secretary, Commissioners of Water Works, Erie, Pa.

Secretary

BEEKMAN C. LITTLE, 305 Cutler Building, Rochester, N. Y.

Editor

ABEL WOLMAN, 16 West Saratoga Street, Baltimore, Md.

Trustees

Term expires 1928	Term expires 1929	Term expires 1930
R. L. DOBBIN Peterborough, Ont.	F. E. BECK Rochester, N. Y.	LOUIS R. HOWSON Chicago, Ill.
GEORGE H. FENKELL Detroit, Mich.	J. O. CRAIG Salisbury, N. C.	SETH M. VANLOAN Philadelphia, Pa.
PATRICK GEAR Holyoke, Mass.	THEODORE A. LEISEN Omaha, Nebr.	GEORGE W. PRACY San Francisco, Cal.

Executive Committee.—JAMES E. GIBSON, WILLIAM W. BRUSH, BEEKMAN C. LITTLE, GEORGE C. GENSHEIMER, ABEL WOLMAN, GEORGE C. ANDREWS, ALLAN W. CUDDEBACK, HARRY F. HUY and the nine Trustees.

Finance Committee.—GEORGE C. ANDREWS, Chairman; CHARLES R. BETTES, E. G. WILHELM.

Publication Committee:—C. A. EMERSON, JR., Chairman; BEEKMAN C. LITTLE, Secretary; ABEL WOLMAN, Editor; L. M. ANDERSON, F. G. CUNNINGHAM, W. W. DEBERARD, C. G. GILLESPIE, ARTHUR E. GORMAN, D. C. GROBBEL, N. J. HOWARD, FRANK C. JORDAN, JOHN F. LABOON, BEN S. MORROW, H. E. MOSES, ARTHUR L. MULLERGREN, W. S. PATTON, RALPH W. REYNOLDS.

Officers of the Divisions

Water Purification Division.—Chairman, WELLINGTON DONALDSON; Vice-Chairman, WILFRED F. LANGLIER; Secretary-Treasurer, HARRY E. JORDAN; Executive Committee, NORMAN J. HOWARD, Immediate Past Chairman, WILLIAM GORE, GEORGE SPALDING and the officers.

Fire Protection Division.—Chairman, NICHOLAS S. HILL, JR.; Vice-Chairman, ALLAN W. CUDDEBACK; Secretary-Treasurer, CLARENCE GOLDSMITH.

Plant Management and Operation Division.—Chairman, W. E. MACDONALD; Vice-Chairman, THOMAS L. AMISS; Secretary-Treasurer, R. B. SIMMS; Trustees, THOMAS HEALY, SAMUEL B. MORRIS.

Officers of the Sections

California Section.—President, JOSEPH R. RYLAND; Vice-President, JOHN BURT; Secretary-Treasurer, WM. W. HURLBUT; Executive Committee, W. F. GOBLE, CHARLES S. OLMSTEAD, and the officers.

OFFICERS OF THE AMERICAN WATER WORKS ASSOCIATION (Continued)

Officers of the Sections

Canadian Section.—Chairman, D. McLean Hanna; Vice-Chairman, J. O. Meadows; Secretary-Treasurer, A. U. Sanderson; Immediate Past Chairman, R. H. Starr; Trustees, W. E. MacDonald, W. C. Miller, Marcel Pequegnat; Representative of Canadian Water Works Equipment Association, J. J. Salmond.

Central States Section.—President, Mentor Hetzer; Vice-President, Daniel C. Grobbel; Secretary, E. E. Bankson; Trustees, W. H. Dittoe, Chester F. Drake.

Florida Section.—Chairman, Anson W. Squires; Vice-Chairman, Eugene Masters; Secretary-Treasurer, E. L. Filby; Directors, term expiring 1927, C. C. Brown, A. P. Michaels; term expiring 1928, L. B. Duane, W. A. Richards; term expiring 1929, F. W. Lane, F. J. Stewart.

4-States Section.—President, Seth M. Van Loan; Vice-President, L. Van Gilder; Executive Committee, N. E. Bartlett, W. H. Boardman, H. D. Brown, J. W. Ledoux, George McKay, and the officers.

Illinois Section.—President, G. C. Habermeyer; Vice-President, C. M. Roos; Secretary, M. L. Enger; Treasurer, H. E. Keeler; Trustees, H. M. Ely, W. R. Gelston, L. R. Howson.

Indiana Section.—President, J. W. Moore; Vice-President, C. E. Stewart; Secretary-Treasurer, C. K. Calvert; Assistant Secretary-Treasurer, L. S. Finch; Executive Committee, E. W. Agar, Harry Garman, J. W. Joplin, F. C. Jordan, Wm. Luscombe, J. B. Marvin, H. S. Morse, F. P. Stradling, W. L. Younce.

Kentucky-Tennessee Section.—Chairman, W. S. Patton; Vice-Chairman, F. W. Albert; Secretary-Treasurer, F. C. Dugan; Directors, S. R. Blakeman, W. H. Lovejoy.

Minnesota Section.—Chairman, G. C. Pruett; Vice-Chairman, J. W. Kelsey; Secretary, R. M. Finch; Trustees, Ole Forsberg, A. D. Horne, D. A. Reed, William Todd.

Missouri Valley Section.—Chairman, Thomas J. Skinker; Vice-Chairman, John W. Pray; Directors, H. V. Pederson, C. L. Ehrhart.

Montana Section.—President, Joseph M. Schmit; Vice-President, Emil Sandquist; Secretary-Treasurer, Herbert B. Foote.

New York Section.—Acting-President, Frederic E. Beck; Secretary, E. D. Case; Board of Governors, Frederic E. Beck, E. D. Case, F. T. Kemble, Wm. A. McCaffrey, Thaddeus Merriman.

North Carolina Section.—President, C. M. Grantham; Vice-President, C. E. Rhyne; Secretary-Treasurer, H. G. Baity; Executive Committee, H. G. Baity, G. F. Catlett, J. O. Craig, C. M. Grantham, E. G. McConnell, H. E. Miller, C. E. Rhyne, W. E. Vest.

Pacific Northwest Section.—President, W. A. Kunigk; Vice-President, Ben S. Morrow; Secretary-Treasurer, Kenneth Shibley; Executive Committee, L. Murray Grant, Alex. Lindsay, and the officers.

Rocky Mountain Section.—Chairman, Paul E. Strouse; Vice-Chairman, L. C. Osborn; Secretary-Treasurer, Dana E. Kepner; Directors, term expiring 1928, D. V. Bell, Paul S. Fox, term expiring 1929, E. C. Gwillim, C. Cicero Ogle; term expiring 1930, E. A. Lawver, A. W. Stedman.

Wisconsin Section.—Chairman, A. J. Hall; Vice-Chairman, W. H. Jackson; Secretary-Treasurer, Leon A. Smith.